ENGINEERING RECORD

A WEEKLY JOURNAL DEVOTED TO CIVIL ENGINEERING AND CONTRACTING

PUBLISHED BY THE McGRAW PUBLISHING COMPANY, INC.

Volume 68 NEW YORK, SATURDAY, JULY 26, 1913 Number 4

Floating Lock Gates The chief novelty of the Keokuk locks, described in detail on page 88, is the floating gates, one of which is also used as an entrance caisson for the drydock. Air-operated lock gates raised by a buoyancy chamber are not unusual in Europe, but most of these gates are hinged at the bottom. The Keokuk gate, however, owing to the favorable condition offered by the deep power-plant forebay, rises and falls vertically, and carries on its 110-ft. clear span a standard-gage railroad track, affording access to the power house. The gate, therefore, is in reality a truss bridge with a skin plate on the downstream truss for waterproofing purposes. The details of the structure have been very well worked out and the gates have operated satisfactorily.

Cisterns for Fire Protection That San Francisco has profited well by the severe fire lesson of 1906 is evident from the article on page 107, describing the new fire-protection system, in which the chief departure is the use of underground reinforced-concrete cisterns, independent of any direct connection with the principal system. The primary and chief reliance is upon a network of high-pressure mains served by a number of reservoirs and two pumping stations, all of which follow in design the same general lines as other installations of a similar nature. However, there was one special danger to be guarded against that did not require consideration in other American high-pressure systems, namely, damage by earthquake shocks. For this reason special investigations were made to find a type of joint best suited to withstand the racking of earthquake disturbances and, in addition, an auxiliary system was deemed advisable to supplement the high-pressure network in case it should be damaged by seismic movements. This auxiliary system consists of the cisterns referred to. They are monolithic and without piping connections, so that they can be moved by a convulsion independently of the surroundings. That they give promise of sufficient stability to resist slight disturbances is indicated by the experience related in the article, in which one of them was floated during a storm and settled back on its bed without injury.

And the Public Pays the Bill When the Newlands arbitration bill was rushed through Congress and signed by the President last week it was hoped that peace would at once be established between the railroads and their employees and that nothing remained to be done but to select the mediators and to proceed to an amicable adjustment of the controversy. Since no fair and final adjudication could be made without a thorough analysis of the working conditions and the services rendered, the managers cited a number of grievances' that they desired to have included in the investigation. The result was exactly what might have been expected—a demand by the brotherhoods that the railroads recede from their position and that the old game of "heads we win, tails you lose," be played in the same old way, with nothing for the employees to lose but everything to gain. Leaving aside any understanding, recorded or implied, which preceded the passage of the Newlands bill, it is certainly politic on the part of the conductors and trainmen in the present juncture to take the large view of the question, to have the whole matter gone over thoroughly and a decision, whether entirely favorable to them or not, rendered on the facts. The difficulty is that the brotherhoods feel that their fight is with the railroads alone and that the two contestants can go out in the lot and "have it out" regardless of any third party. In fact, the third party, when considered at all, is relied upon to use its influence to whip the railroads into line. Nevertheless, the temper of the third party—the public—is changing, for the public pays the bills and before long will demand that its rights be respected even if that should require the regulation of the employees even as the railroads are now regulated. While apparently the unions have a tight grasp upon Congress, as was evidenced by the passage of the labor immunity rider in the sundry civil bill, the representatives at Washington have their ears close to the ground and will be quick to catch the louder rumbling that will come from the general public. In the interests of a fair and final settlement, under present conditions, it is hoped that the brotherhoods will consent to a sweeping investigation and not merely to the arbitration of their "grievances." The rights of the public demand that both sides forego formalities and open the way for a settlement of the entire controversy strictly on its merits. As a final word, it is not amiss to point out that the railroads in the past few years when strikes were threatened have given far more consideration to the rights of the public than have the employees.

The End of the Job The final stages of a large undertaking bring with them a certain element of regret as the engineers and field superintendents begin to see the ruthless dismantling of machinery and equipment in which during the days of mighty accomplishment they took so much pride. Still there is a lot of satisfaction in seeing all parts of the work dovetail together and observing the tuning-up process which tests the pet theories and moot questions discussed over the drafting board and in the field. It is then that the men begin to get anxious for the next undertaking, for larger problems, to which they will bring added experience and still newer ideas. The construction work of the Mississippi River Power Company is practically at an end and on page 88 is a description of the last large hydraulic feature. On any great undertaking many more articles of interest and value could be written than it is possible to print, but this journal has endeavored to follow the Keokuk work step by step from inception to completion because of the widespread interest shown, the many new construction methods brought out and the numerous advances in the design of hydraulic structures and equipment. It is timely to mention that the chief engineer and his assistants, who have not only designed but also built the plant, have given the technical and local press unlimited opportunity to obtain information at every stage in the progress of the work. This policy has enabled engineers to follow it practically as fast as construction proceeded. Undoubtedly the interest thus aroused has brought numerous persons to the work for a personal inspection. Had all data been withheld until the plant was finished to "see if it would work" there would have been a series of scrambled articles presented for the reader's review extended to such a length that he would likely have placed the paper aside to read when he had more time—a northern man's way of saying mañana. The present tense always makes better and more interesting sentence construction than the past. The Engineering Record is of the opinion, too, that the liberal way in which the layman has been made acquainted with the details of construction at Keokuk tends to raise the estimation of the engineering profession in the mind of the public. Looking backward it is of interest to note that 10,000 carloads of machinery and supplies have been distributed to their final location. More than two thousand six hundred drawings have been made, and the designs called for built into a pulsing, enduring monument to the courage and ability of the men behind the project. The original schedule called for power to be delivered in June, and on July 1 during the rush hours over two-thirds of the street cars in St. Louis were getting Keokuk power. "Finished on time" is, therefore, the final word—another tribute to the organizing ability of Mr. Cooper and his assistants.

Water-Waste Prevention Using all the water available is the practice in which not a few communities indulge every summer. It is estimated that Chicago wastes 50 per cent of the water pumped, by contrast with which the 17 per cent waste in Milwaukee is of interest. Salt Lake City is using at times all the water the conduits can supply, over 400 gal. per capita, and still there is so little co-operation between the water and street departments that the former is unable to prevent the constant flushing and continual flow of water in the gutters that would lead one to believe that in Salt Lake City at least water must be as "free as air." In Terre Haute the water company combats wanton waste by well-worded advertisements in the local papers, in every issue of which new lines of thought are expressed. One notice, headed "The Public Be Pleased," gives the idea that the majority of the consumers use water in a proper manner, that it is necessary to use a great deal of water in hot weather, that a comparatively few wasteful and careless persons must be restrained and that the company must, in its endeavors to please the general public, curb the unusually improvident. In more than one Western city it has long been the policy not to attempt to curtail the use of water as long as there was an overabundance available, so that in Denver, for instance, the maximum consumption often runs above 300 gal. per capita. The overtaxing of supplies often leads to entirely erroneous ideas. At Minneapolis, for example, when the conduits were taxed to their capacity little mention was made of waste, but undue emphasis was laid on the inadequacy of the new filter plant and on the need of immediate extensions. There have been popular campaigns against waste in a number of cities, but there is still room for additional active work. The Terre Haute method is a good one. Where the supplies are owned by the community help can always be secured from the local press. In many cities there exist municipal newspapers in which the space now given up to uninteresting tables of "water permits issued" might well be used to tell a few facts about water-waste prevention. Dry statistics are not read and are always accessible in better form in the waterworks office to the few people who have use for them. Mr. L. E. McGann, commissioner of public works of Chicago, proposes to curtail waste by reducing meter rates and thus popularizing the use of meters. At present the metered services consume only 24 per cent of the water pumped, but pay 46 per cent of the revenue. Discussion in technical societies and in engineering journals has been carried on to such an extent that there can be few waterworks officials who remain to be convinced of the necessity for water-waste prevention. General public education must follow, and waterworks men must furnish the educational literature, or at least the data on which it is based.

New York's Smoke Ordinance

The Court of Special Sessions of New York City, in the case of the State against the New York Edison Company, has decided that the provision of the sanitary code of the Board of Health prohibiting the discharge of "dense smoke" from buildings, vessels, stationary or locomotive engines within the city limits is "unreasonable and arbitrary because of its unqualified and sweeping character, condemning as a nuisance a thing that may or may not be a nuisance, and because it makes no provision for cases where compliance is impossible." The court further states that the present ordinance, prohibiting, as it does, the emission of dense smoke, irrespective of reasonable definitions, limitations and qualifications, is a restriction upon the use of private property and repugnant to the provisions of the Federal and state constitutions, that no person shall be deprived of his liberty or property without due process of law.

Such an outcome was to have been expected under the city's present regulations governing the production of smoke, for who is there to draw the line between "dense" smoke and smoke that is not "dense" unless there be some definite basis by which the density of smoke may be measured? The intent of the sanitary code is excellent, but its wording is unfortunate in not defining the term "dense smoke" and in not recognizing that a reasonable production of smoke is essential to the conduct of industrial enterprises. The ruling of the court, therefore, makes the section of the sanitary code as it now stands void and inoperative. It is, perhaps, just as well for New York that such is the outcome of the case, for now the city may look forward to a revision of its rules and the passage of a workable ordinance.

It is interesting at this time to reflect that Boston in 1910 was confronted with a problem similar to the one which New York must now solve. The Boston ordinance contained a "dark or dense-gray-smoke" joker, and it was not until the Massachusetts Legislature provided for the classification of smoke densities by means of the Ringlemann smoke chart and permitted the emission of dense smoke for certain brief periods at definite intervals that the regulation of the smoke nuisance could be carried out effectively. Such a law as this, instead of the present one, is what New York needs. In fact the promise of a new ordinance is the silver lining in the sooty cloud which seemingly is rolling onward to envelop New York since the ban on smoke has been temporarily lifted.

Improvements on the Louisville & Nashville Railroad

On page 97 is the first of a series of articles on the extensive work on the Louisville & Nashville Railroad. This is one of the most important grade-revision programs under way in the United States, and is probably the largest ever undertaken in the South. As the article states, the work consists of two independent programs—the main-line work in Tennessee and Alabama and the branch-line improvements in Eastern Kentucky. Although some of the heaviest work is in the Kentucky section, the main-line project is much more extensive, covering the entire district from Nashville to Birmingham, these 200 miles constituting the most congested part of the main line from Cincinnati to New Orleans. When the improvement is completed the capacity of this section will be tremendously increased.

The 100-mile new line from Brentwood to Athens is in itself no mean undertaking. As the old line ran through established communities it was not feasible to abandon it, though the new line will ultimately carry the bulk of the traffic. With this in view, provisions are being made for future double-tracking, but this is not being overdone. For instance, small culverts, in which the cost of 13 ft. of barrel is small in comparison with the cost of end and wing walls, are being built for two tracks. On the other hand, such structures as can be readily extended to accommodate an additional track are being built for single track at present.

Accepted practice is being followed in the use of solid embankments in place of open bridges as far as possible and advisable. Reinforced concrete is being used extensively in box and arch culverts, undercrossings and bridge abutments. The Louisville & Nashville has a reputation for conservatism, and some of the other conservative roads that shrink from reinforced concrete as from a pestilence might find it profitable to look into these designs and the results obtained.

One feature of the profiles that should not be overlooked is the recognition of a definite relation between ruling and pusher grades. Pusher grades too often waste power, because while they cannot be negotiated with one engine they do not take the full power of two. Many roads are designing locomotives to fit their grades, but in new construction do not always fit the grades to the locomotives. The exact figure for an economical pusher grade cannot be computed, because too many elements enter into level-grade resistance, but it is believed that if one engine can overcome the level-grade resistance of a train and that due to the 0.5 per cent ruling grade on the Decatur-Birmingham section, a second engine of the same type can overcome the extra 0.75 per cent on the pusher grade. In the same way, though less exactly, the 0.4 and the 0.9 per cent grades on the section north of Decatur are expected to balance. It is probable that even if these pusher grades could be reduced to, say, 0.7 and 0.55 per cent respectively, no advantage would be gained; they would still need pushers, but there would be the invitation to reduce the train load slightly, do away with the pusher and get the trains over somehow—resulting in breakdowns, accidents and general confusion.

Publishing Hydroelectric Power Rates

Within the last few years the publication of rates for electric service by central stations has become so common that it is now a rare experience to find a company which does not print its charges and often their full explanation in a neat folder for general distribution. A corresponding demand for information from hydroelectric power companies regarding their methods of charging for service is not so easily met, however, and there is no doubt that in some cases the difficulty of quoting rates for popular use has led to misapprehension of the policies of such organizations. The layman does not realize that because he can walk into the local office of his electric-light company and in ten seconds receive a full and carefully prepared explanation of the rates in force he cannot for that reason expect to do the same thing in dealing with the large wholesaler of electrical energy.

The differences between such organizations are apparent upon a little consideration. The usual city system retailing electricity to thousands of customers consuming relatively small amounts of service individually is a compact affair, representing, no doubt, a heavy investment in plant and distributing system, but serving a dense population within an area so small geographically that the addition of new customers' installations seldom introduces serious or burdensome additions to the existing investment, looking at the effect of individual services. The overhead lines or underground cables pass many doors where new business can be secured with little added equipment cost to the operating company; line voltages are low in comparison with those used in transmission work; and in general, the problems of taking on new loads are simple, once the company secures the contract to handle the business. The average cost of serving customers of different classes can be estimated with sufficient accuracy to justify the maintenance of standard rates for stated connected loads and for different energy consumptions, and this means that the company can easily publish an iron-clad schedule of prices—and, what is more, adhere to it—throughout all of its local territory, accepting business that comes to it on the basis of settled rates and with confidence that the great majority of installations can be profitably supplied without further efforts to arrive at a price.

Just the opposite is the case with the hydroelectric-power system. In a typical instance a large company serving two or three counties may have only thirty-five customers, and the conditions surrounding the use of electricity in each plant are very likely so diversified that each contract for service must be made independently. One plant is located 3 or 4 miles off the 60,000-volt trunk line, necessitating a corresponding amount of special construction to reach him; another happens to be near enough two or three other large users of the service to warrant the construction by the company of a special distributing substation for the group of consumers; still another demands primary power the year through, and a fourth gets along very well with secondary power subject to interruptions, perhaps utilizing former steam-generating equipment in a reciprocal-power contract. Times of service, load factors and many other conditions may come into the case, with the net result that while the average charges can be stated to the public in a general sort of way, it is almost impossible to present the rates in extenso in a form which outsiders can use to advantage.

The situation is simply that the engineers of the large system stretching over many miles of often thinly settled country must, for the present at least, be permitted to figure the requirements of individual cases without being too closely tied to the tabulated charges which bind the city company, and in most of these cases the business cannot be secured without the service being a source of additional economy of operation for the user, since it must in almost all instances compete with existing or possible self-contained generating plants which can be set up anywhere that the prospective consumer desires. This necessity of meeting existing costs fairly is an excellent check against extortionate charges.

Doubtless it adds to the public's good-will toward the company if a folder giving the range of prices usually in vogue, with an explanation of the need of departures therefrom in many individual cases, is published for distribution by the power company; but the management of the latter should in no wise be charged with discrimination if it insists upon making prices only after careful engineering investigations. In the past there has been too much secrecy about hydroelectric-power prices; but newer and better ideas are coming to the front. With more publicity of the reasons why specific rates are made as they are there is no reason why such companies should not be allowed by the public to continue to make highly diversified charges so long as the territory served is sufficiently undeveloped to demand careful technical study in offering to supply service to particular installations.

Recirculated-Air Ventilation

The proposal to ventilate buildings by recirculating the air and keeping it in motion without adding fresh air is not a new one, but tests on more than a laboratory scale are of recent origin. At the present time studies are under way at a number of points in the United States, and at the meeting of the American Society of Heating and Ventilating Engineers in Buffalo last week Prof. Frederick Bass, of the University of Minnesota, recounted the experiments made under his direction at a Minneapolis public school.

The air from one of the rooms was used over and over for three weeks without addition of fresh air, other than by leakage through crevices and doors occasionally opened. The only treatment consisted in the introduction of 1 part of ozone per 1,000,000 parts of air in order to get rid of the "crowd odor." The air was delivered to the room through a 2-in. duct at each desk, the current enveloping the head and shoulders of each pupil. Two lines of ducts, in addition, were placed along the sides of the room, so that with the air supplied at the desks the volume was 8 cu. ft. per minute per pupil. The theory of the scheme is that a human being may suffer severely from stagnant air, especially when its temperature and humidity are high, while with air in motion and of moderate temperature and humidity there will be no discomfort or adverse physiological results.

In the Minneapolis experiment physiological and psychological tests were made upon the children and also upon a "control group" supplied with fresh air, in order that the difference between the two groups might indicate the effects of recirculated air. Professor Bass concludes as a result of his study that there has been no appreciable effect upon the pupils in the test room. He goes on to say: "The results show conclusively that in rooms and auditoriums only occasionally used the revolving and renewing of air by proper treatment are as desirable as the use of outside air. . . It seems probable, too, that persons may occupy rooms ventilated by renewed air for a great length of time, certainly for periods as long as three weeks, without suffering or even exhibiting any effect either consciously or unconsciously. Air leakage will supply more than enough oxygen."

It is doubtful, however, whether the tests made by Professor Bass warrant these rather sweeping conclusions. There is a possibility that had the test been continued somewhat longer adverse effects might have been shown —in other words, that while there may be little harm in living under such conditions for a short time a continuation in such an environment would tend to lessen vitality. That, too, was the consensus of opinion at the meeting in Buffalo. While the experiments are very interesting and point a way to further study and a possible revision of ventilation standards, it is certainly too early, with only these studies as a basis, to abandon the present educational campaign for the admission of as much fresh air and life-giving oxygen as possible.

Influence of Basicity on Protective Value of Paints for Metals

The article by Mr. Henry A. Gardner on page 93 of this issue gives the first clear general statement of the net results of the discussions that have been going on for the last five years on the question of stimulative and inhibitive paint pigments.

When the idea was first advanced that some pigments stimulate while others retard or inhibit the corrosion of iron or steel, and when Dr. Gustave W. Thompson brought forward the water suspension test, it was thought by many that we were at once to determine accurately and quickly the relative values of all the paint pigments in use or which could be used. After a committee of the American Society for Testing Materials had subjected about fifty pigments to the Thompson test and had divided them in general into these groups, designated as inhibitive, intermediate (or indeterminate) and stimulative, it was decided to check up the results by applying the same pigments in the form of paint to steel panels and expose them to the weather at Atlantic City, all of which has been described in detail in the Engineering Record. The results of the Atlantic City test were to many observers more confusing than illuminating because of the excellent protection offered by a few of the pigments which had appeared in the Thompson water test to be rather stimulative in their action and because of the rather poor protection offered by one or two pigments that had given evidence of being inhibitive in the water test. Although in general the results obtained in the fence test agreed sufficiently well with those obtained by the Thompson water test to indicate a practical relation between the two, yet the individual cases of seemingly contradictory results were sufficient to allow many observers to draw their own and varied conclusions from the test. Each paint man, therefore, saw demonstrated at the Atlantic City fence his pet theory of what pigments to use and what not to use. By applying one explanation for the failure of this and another for the failure of that pigment; by accounting for the success of pigment X by one theory and for the success of pigment Y by a totally different theory, the paint men were in general able to convince themselves that what they had thought all the time was quite correct. No single explanation had been found which would reconcile the differences in the results obtained.

Now comes Mr. Gardner with an explanation and argument that really tries to explain why one pigment protects an iron better than another. While the Engineering Record does not attempt to say whether the explanation offered by Mr. Gardner is final, yet it does appear to be applicable and logical in more cases than any other single argument yet advanced.

The fact that red lead containing litharge or red lead to which litharge has been added offers a better protection to steel than a red lead practically free from litharge has been demonstrated by Mr. Gardner, by other experimenters and in the field. Certain manufacturers of structural-steel paint have been using litharge in moderate quantities in place of straight red lead for structural-steel paint for several years. By using it in combination with other pigments they overcome the hardening which is so troublesome when litharge and oil alone are mixed together.

Whether or not the lead-oxide content of sublimed blue lead is really litharge in another physical condition so different from that in which it ordinarily occurs as to have practically no drying action upon linseed oil is probably open to discussion. This question of nomenclature does not, however, affect the broader question as to whether the protective value of the pigment under discussion is due to its basicity.

The question of the value of "purity" in a paint is one which might be discussed along various lines, but all of them lead back to the starting point. The specific for the complicated "disease" of iron, called "rusting," will probably not be found in a single chemical compound, however "pure" it may be.

The very valuable influence of an inhibitive coating in the prevention of the spread of rust from pinholes or abrasions in the surface is of the utmost importance. As pointed out in the article, the rusting of the iron surface may proceed with marked rapidity under a stimulative coating once a break is formed in the continuity of the coating. This quality of preventing the spread of rust from abraded spots or pinholes has been given an important place in some of the exposure tests made in recent years. On the Atlantic City test fence the coating on each plate was intentionally abraded by scratching a line across the corner of each plate; the difference in the rate at which the rust spreads under various paint films on the sides of the scratch forms an important index of the protective value of the coating.

The use of coke-oven and gas-works tars and asphalt solutions in paints for structural steel has not shown very encouraging results when these products are used alone. As a final coating over a good inhibitive priming paint of sufficient body to form a base on which to apply the hydrocarbon products they have in many cases shown very satisfactory results even when exposed to direct and strong sun action. This may be due largely to the action of the undercoating in holding the tar or asphalt outer coating in place and preventing "alligatoring."

The rapidly broadening field of useful paint constituents is evidence of the great amount of work being done to find other and better paint materials than have been in general use in the past. The progress made has undoubtedly been great and gives good reason for the hope that the permanency of iron structures will be greatly increased in the not-far-distant future.

Lock and Drydock at Keokuk

New Type of Disappearing Gate for One of the Largest Locks in the World, Operated from a Central Station by Compressed Air

Vertically operated floating gates are employed at Keokuk, Ia., on the new lock and drydock which the Mississippi River Power Company is building for the U. S. Government to replace the three locks and 9 miles of canal submerged by the construction of the dam and power plant which have been described in the Engineering Record of Aug. 5, 1911, page 149, and of Nov. 16, 1912, page 536. On May 8 water was turned through the first of the fifteen 10,000-hp wheels, and since July 1 electrical energy has been transmitted regularly to St. Louis. The lock is complete and the first boat passed through it on June 12. The drydock site is being filled and will probably be complete by Sept. 1.

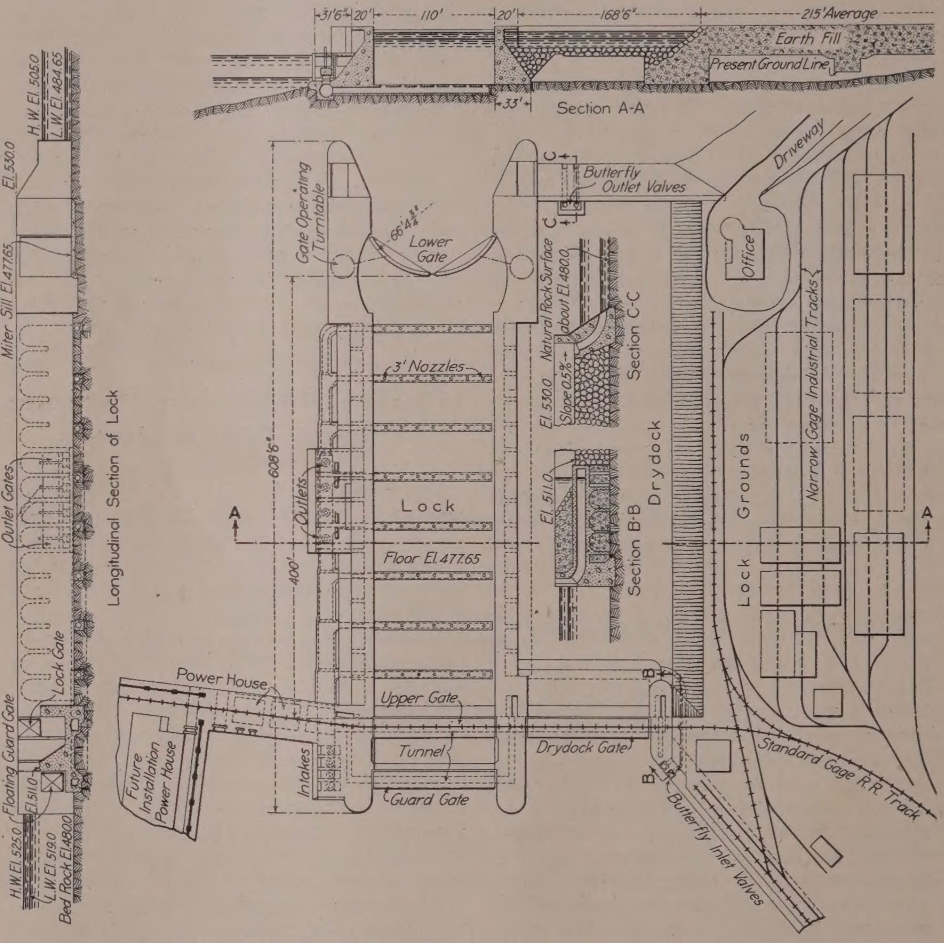
The lock, drydock and lock grounds are located on the Iowa side of the river. As the existing lock occupied space under the new drydock, it was possible to maintain traffic during the construction of the new lock. Features included in the works, which will be turned over to the U. S. Government, are a lock, 110 ft. wide by 400 ft. long, with a lift of 40 ft.; a drydock 150 x 463 ft. in plan, a power plant of 400-hp capacity for operating the gates located in the wall connecting the lower end of the main power house and the upper end of the lock, an intake and discharge system controlled at inlet and outlet by four air-operated cylindrical gates, swinging steel miter gates at the lower end of the lock, interchangeable floating gates of a novel design for the upper lock gate, the guard gate and the drydock and an elaborate central system of control of the compressed air by which all of the machinery is driven. Below the mitering gate is a needle dam by which the tailwater may be excluded to permit laying dry the floor of the lock and the culvert system.

Foundations for the various structures were excavated from the limestone ledge, which is so nearly level at El. 480 that little or no trimming was necessary. The lock floor is not covered with concrete except to fill in around the culvert pipes.

The original cofferdam inclosed practically all of this work with the exception of a portion around the lower end of the old lock, through which traffic was not interrupted until the new lock was ready to operate.

Lock Walls

Walls of the gravity type, built of 1:3:5 concrete, form the sides of the lock. They are 33 ft. wide at the bottom and 8 ft. wide at the top below the 20-ft. esplanade, supported on inset arches, which also give stiffness to the walls. At the lower end the walls are 40 ft. wide and have vertical faces, the extra weight being required to withstand the thrust of the mitering gates. At the upper end the walls are 30 ft. wide and have vertical faces. Between the guard gate and the upper gate the width between walls is enlarged by 5 1/3 ft. This will permit removing the upper gate, as it may be swung on its vertical center opposite the recess sufficiently to clear the seat of the emergency gate.



Plan and Cross-Sections of Lock and Drydock at Keokuk, Iowa

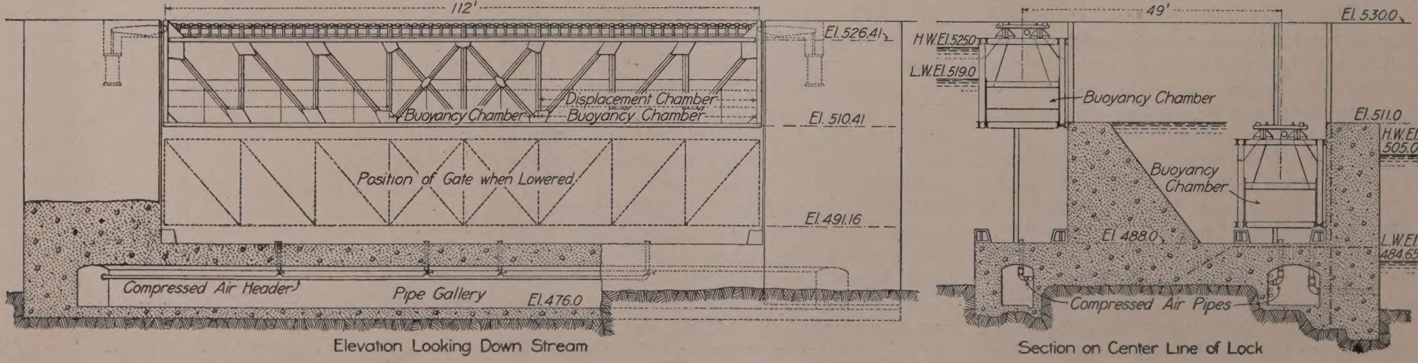
Construction of the lock proceeded from the lower end, where there was the greatest bulk of the concrete. Wooden form sheets, or panels, made up of 2-in. lagging and 4 x 4-in. studs were held in place by rods embedded in the concrete and by wiring across to the forms on the opposite side of the wall.

Mixed concrete was brought to the site from the mixing plants at the upper end of the power house over industrial tracks in 1½-yd. buckets and then hoisted to place by stiffleg derricks mounted on three improvised railroad trucks. When the height of the wall became too great for handling material from below the derricks were mounted on top of the portion of the wall already completed.

Filling and Emptying System

For filling the locks with water and later discharging it a gridiron of eight 6-ft. culverts extends transversely across the lock from a steel header laid under the river toe of the east wall. Each culvert has seven 3-ft. nozzles. The header is 13 ft. in diameter at the inlet end and diminishes in size as each lateral is taken off. Water enters at the point shown in the drawing through four pneumatically operated cylinder valves, 7 ft. in diameter, housed in separate concrete inlet chambers, 19 ft. 8 in. x 10 ft. 6 in. in plan. The centers of the valves are 9 ft. from the back face, giving a clearance of 5 ft. 4 in. Stop-log grooves are provided to permit inspection and repair of the valves.

Each piston is connected to an air cylinder



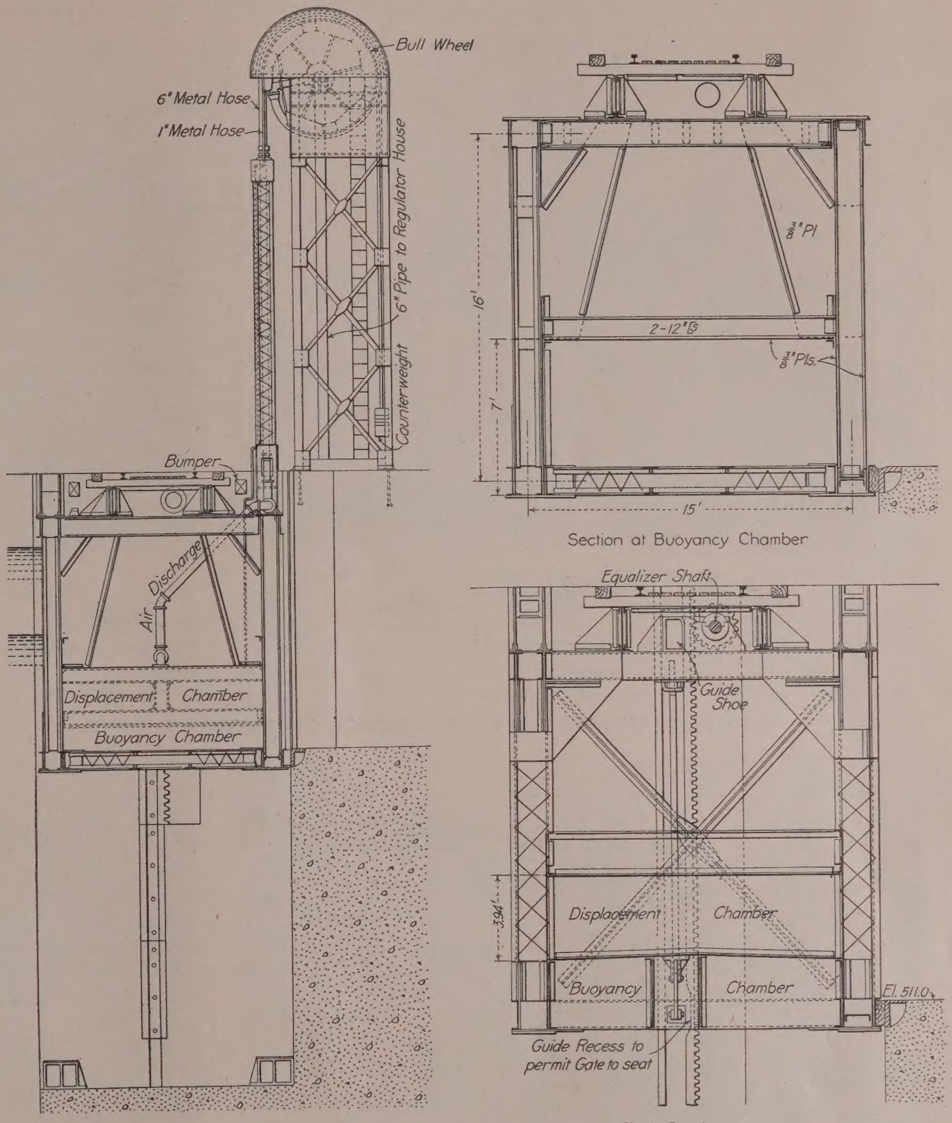
Elevation Looking Down Stream

Section on Center Line of Lock

Details of Floating Gate, Showing Location of Tunnels, Air Piping, Latches and Seats which is supported on the top of the lock by a concrete arch over the chamber. The bonnet, or hood, over the piston rests on two distancers, or pedestals, which in turn rest on a flared inlet casting over the vertical 6½-ft. intake conduit leading to the steel header line. Developed, the clear opening for the passage of water through each valve is 2 ft. 8 in. high by 20 ft. long.

Discharge from the lock takes place through the culvert system to four cylindrical valves, of the same size and type as those at the intake, located in separate discharge chambers near the center of the lock on the outside of the river wall. The valves are set on top of flared nozzles, resting directly on the header, which is 10 ft. 11 in. in diameter at this point. Over the bonnets of the valves are concrete struts, 8 ft. deep and 12 ft. wide, designed to withstand the upward thrust due to the hydrostatic pressure. The operating mechanism is supported on an arched concrete platform over the chambers similar in construction to that at the intake. It is 23 ft. below the top of the back wall and 2 ft. above high tailwater.

Between the normal water level points the lock holds 1,500,000 cu. ft. of water and requires about fifteen minutes to fill. The culvert system is designed to provide a uniform delivery of water throughout the entire area of the lock chamber when filling and an evenly distributed suction when emptying. During the first half of the total time consumed in emptying the lock chambers the water drains down until the difference in head between the level in the lock chamber and the river is about 15 in. The mitering gates and their operating machinery were designed to overcome the usual allowance for wind pressure, and also the pressure due to a difference of 15 in. in water levels. In other words, these gates may be, and actually are being opened against a 15-in. head, thus cutting down materially the discharge period.



Section at Buoyancy Chamber

Detail of Air Discharge

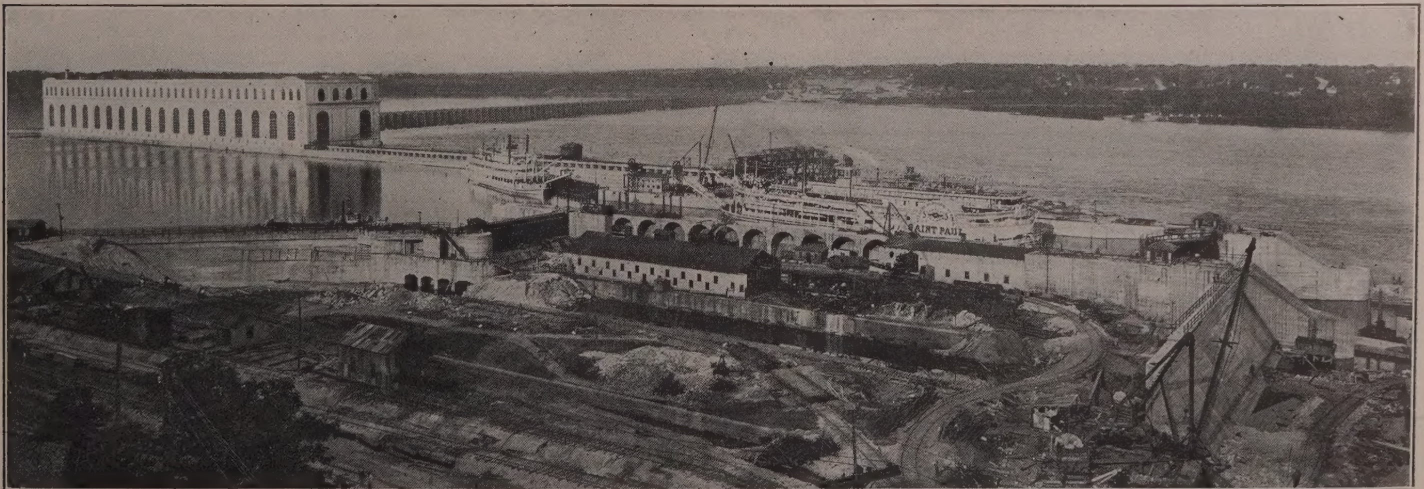
End Section

Details of Floating Gate with Air Discharge and Gate-Alignment Devices

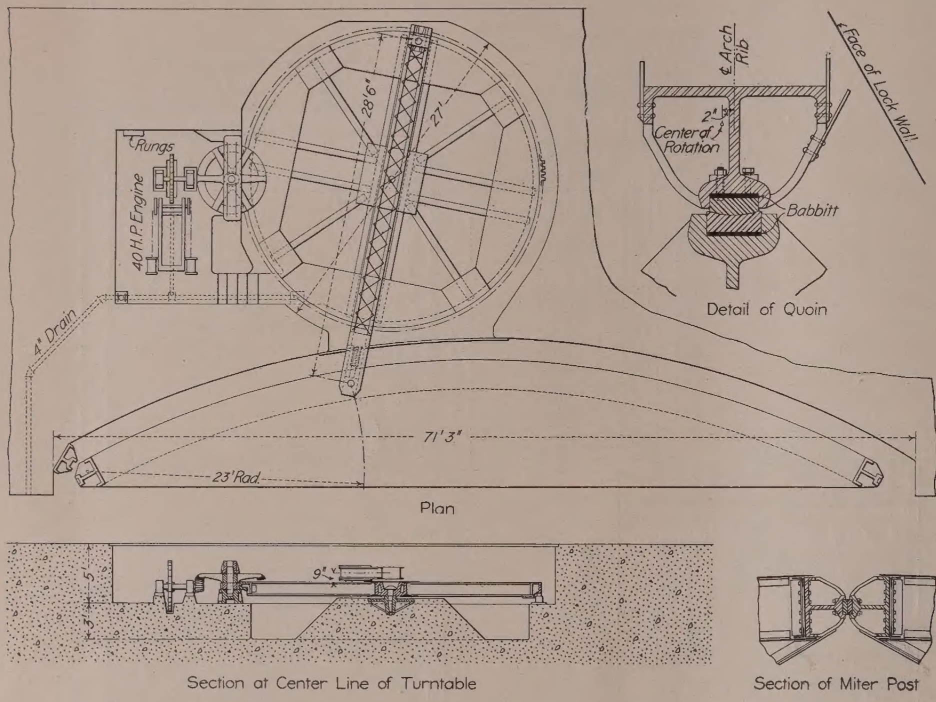
Floating Gates

Choice of vertically operated disappearing floating gates was made possible because of the depth of the pool above the lock. There are 31 ft. of water below the sill and a minimum of 8 ft. above it. At high water there are 14 ft. over the sill, above which the skin plate on the back face of the gate forming the water barrier rises 16 ft. Some of the reasons for adopting this type of gate are: First, the structure could be used as a railroad bridge; second, it reduces the length of lock walls over that necessary for mitering gates; third, there is no outward end thrust—in consequence the walls can be made lighter; and fourth, in case repairs are necessary the three gates are interchangeable and any one can be raised and floated out of its recess to the drydock, or to replace either of the other two gates without removing any part, or without assistance other than towlines and barges lashed alongside to prevent turning turtle.

Each gate has an inverted steel box open on the bottom, located centrally, and two closed displacement compartments, one at each end. Structurally the gate consists of two vertical trusses, 112 ft. long, spaced on 15-ft. centers, and connected in the plane of the top chords by a horizontal truss and in the plane of the bottom chords by lateral bracing, all in the form of an eight-panel Pratt truss-deck railroad bridge. The downstream truss is, in fact, a plate girder and its web is heavily reinforced to sustain the hydrostatic pressure, thus forming the waterproof barrier



View of the Works at Keokuk, with the New Lock and Drydock on the Right-Hand Side



Plan

Detail of Quoin

Section at Center Line of Turntable

Section of Miter Post

Details of Mitering Gate and Its Operating Mechanism

of the gate. The resulting pressure along the top chord of this truss is sustained and carried to the lock walls by the horizontal truss of the top of the gate. The bottom chord and the end frames of this girder are fitted with oak contacts which take bearing upon and transmit the pressure to cast-iron sills bedded in the masonry sill and walls of the lock.

Displacement Chamber

The flotation of each gate is by means of two displacement chambers of 4550-cu. ft. volume and the open bottom buoyancy chamber. The 6200-cu. ft. volume of displacement in the buoyancy chamber is under the control of the operator, located in a central control house, whereby each gate may be opened or closed—that is, lowered or raised at will. Compressed air is conducted from the lock power house through the pipe galleries to two points under each gate.

The oak bearings along the bottom and ends of the gate are not in contact with the masonry or the reaction castings at any time except when the gate is in a closed position. Each gate is confined to position and to transverse alignment by guide runners sliding in vertical cast-iron guides bedded in the lock walls at each end of the gate. These guides have toothed racks which engage a pinion at each end of the gate and, as each spur wheel is keyed fast to a shaft which extends from end to end, the simultaneous movement of every part of the gate and its longitudinal alignment are assured.

Each gate is locked in the closed position by four heavy latches, operated pneumatically by a single air cylinder for each pair.

Each gate is proportioned to sustain the hydrostatic pressure due to water at El. 525 on the upstream side with no water pressure acting against the downstream side. The top truss will sustain 2100 lb. per lineal foot uniformly distributed load. This represents the portion of hydrostatic pressure accumulating along the top flange of the downstream girder, which is the same as the bottom chord of the horizontal truss. For the vertical trusses acting as a bridge the dead load is the entire weight of the structure in air, applied equally to the top and bottom chords, when the bridge is supported on the latches. The live load assumed is a continuous train of Cooper's Class E-40 locomotives, with the bridge supported on its latches in air.

Ballast was fixed in the closed chambers to float each gate on an even keel and level longitudinally. The calculated displacement necessary to float the gate when submerged is 6000 cu. ft. Of this volume there are 4550 cu. ft. in the displacement chambers, and the remainder is provided by the buoyancy chamber by a depth of 3.87 ft., in which the air pressure varies from 7.4 to 13.6 lb. per square inch, according to the location of the gate between the water surface and the extreme low position.

Air for the buoyancy chamber, under 100-lb. pressure, is compressed in the power house and piped through the tunnels under the gates. Two 4-in. risers pierce the roof of the tunnels and discharge into the water through which the air bubbles up under the gate and is trapped.

Discharge of air from the buoyancy chamber is from one point near the center through a 6-in. main carried to the end of the gate and upward through a latticed end-post extension leading to a 6-in. metal hose wound on a bullwheel 8 ft. in diameter. Seven-eighths of a turn of the wheel equals the travel of the gate. The inner end of the hose is connected to the hollow shaft on which the wheel turns. The outer end of the shaft connects with a 6-in. pipe leading to an opening in the lock wall by way of the operator's house, where control is effected.

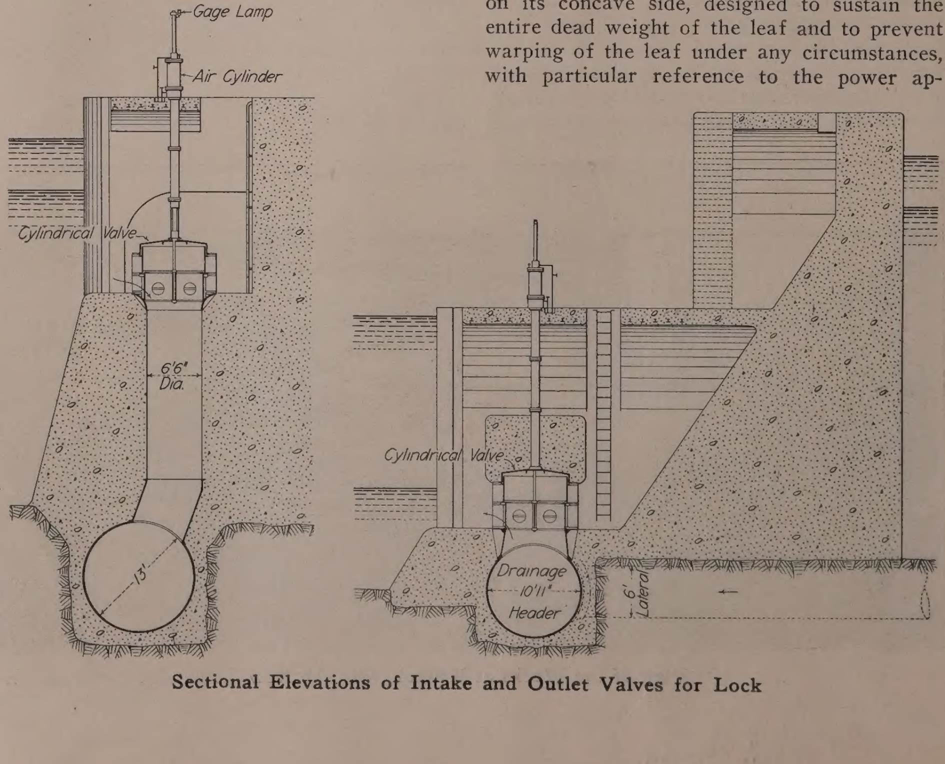
In a similar manner, the bullwheel carries a 1-in. pipe to supply compressed air to the closed chambers for the purpose of removing any leakage through suitably arranged sumps and check valves.

Before lowering the gate air is first let into the buoyancy chamber to raise the gate so that the latches may be removed. There is a permissible upward movement of 9 in. when four bumpers with rubber cushions are encountered. The outlet valve on the air line passing over the bullwheel is then opened and the gate sinks, slowly and under perfect control, to open position. In this downward movement additional air is admitted after the gate is submerged to compensate for the elastic displacement in the open bottom compartment. This gate travels through 19 ft. vertically, and while its movement is kept slow for safety, the change from open to closed position, and vice versa, is accomplished in remarkably quick time.

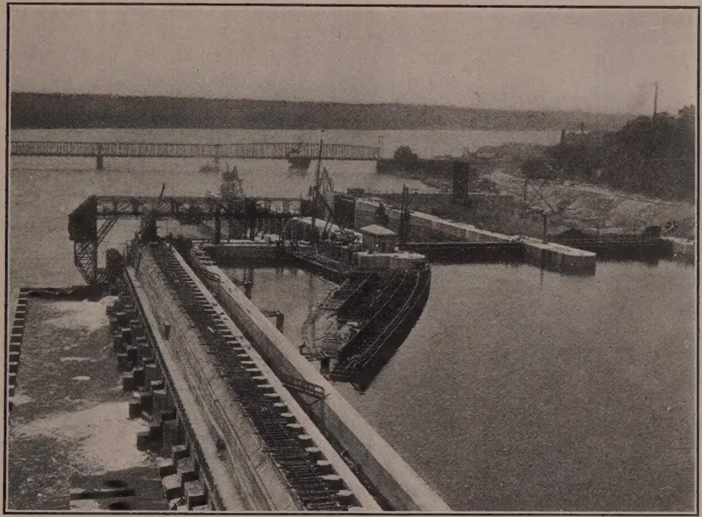
The Mitering Gates

At the lower end of the lock are steel mitering gates, 48 ft. high center to center of extreme arch ribs, 66 ft. 4¾ in. long, center to center of contacts, and 10 ft. 8½ in. in extreme thickness. A displacement chamber at the lower central portion of each leaf supports a large part of its dead weight.

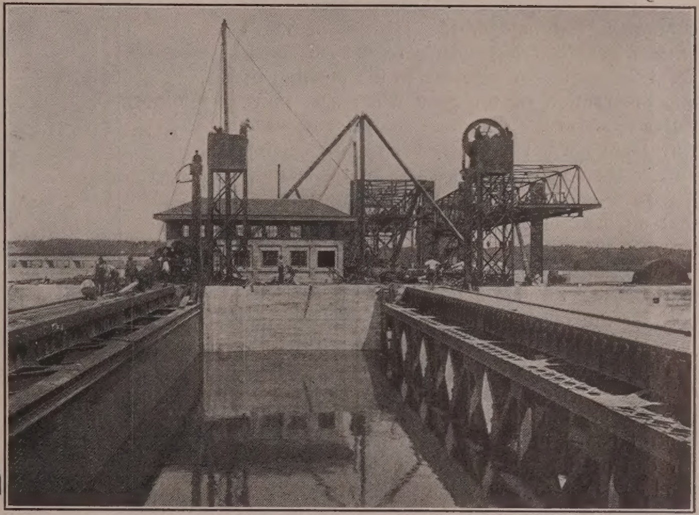
Each gate leaf consists of thirteen arched ribs framed together from top to bottom of the leaf by girders forming the quoin and miter posts and by nine lines of intermediate framing. The quoin and miter posts are further reinforced and pressure from the arch ribs is distributed by cast-steel castings in a continuous line from top to bottom. This frame is covered on its convex side by steel plates. The curved shell of the leaf thus formed is reinforced by heavy steel X-bracing on its concave side, designed to sustain the entire dead weight of the leaf and to prevent warping of the leaf under any circumstances, with particular reference to the power ap-



Sectional Elevations of Intake and Outlet Valves for Lock



Power-House Extension, Lock and Drydock

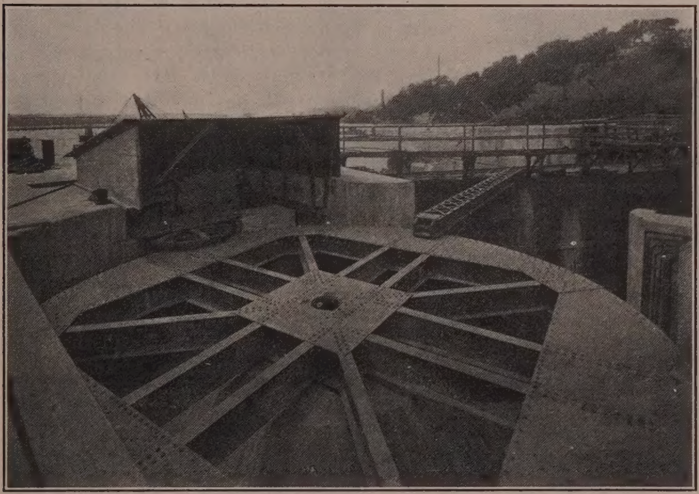


Floating Lock Gates and Air-Connection Towers

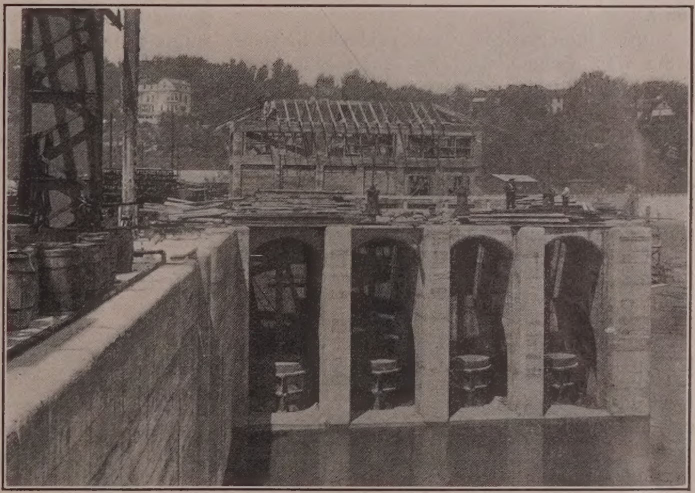
plied eccentrically at the top to open the gate against a 15-in. maximum head of water.

Five conditions of loading were assumed. Case 1 is for the dead load of the gate leaf when hung on its hinges in air. In case 2 the dead load is considered when the leaf is hung on its hinges in maximum high water, thus giving the maximum uplift from the buoyancy chamber. Case 3 is with the gates closed and subjected to sufficient power applied at the top to open them against a 15-in. head at low stage. Case 4 is with the gates closed and subjected to static water pressure, when the lock chamber is filled to El. 525 and tailwater is excluded from contact with the gate, also with contact on the miter post, but not on the miter sill. Case 5 is the same as case 4, with the exception that contact is considered on both miter sill and miter post.

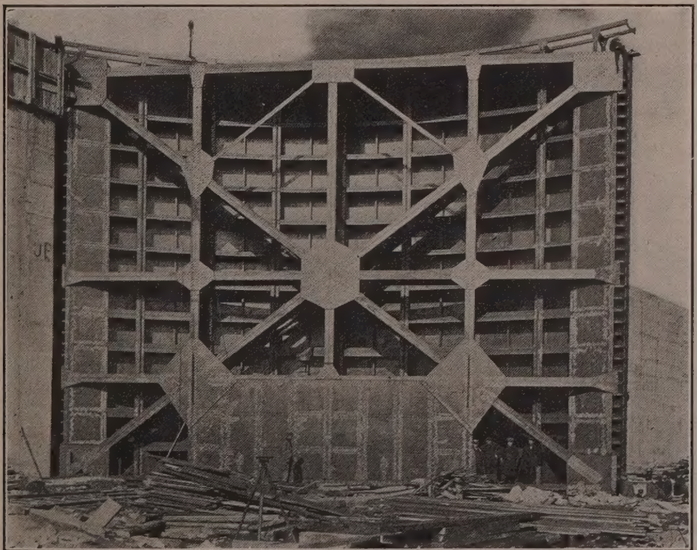
Operation of the mitering gates is by machinery similar to that in use at Panama, except that the motive power is compressed air. The 25-ft. turntable and the strut attached to the gate leaf about one-third of the distance from the bearing are shown in one of the illustrations. The reduction in gearing from the 40-hp reversible air-driven engine to the wheel is 1 to 700. One-half turn of the turntable opens or closes the gate, so that gear teeth are provided for only a little



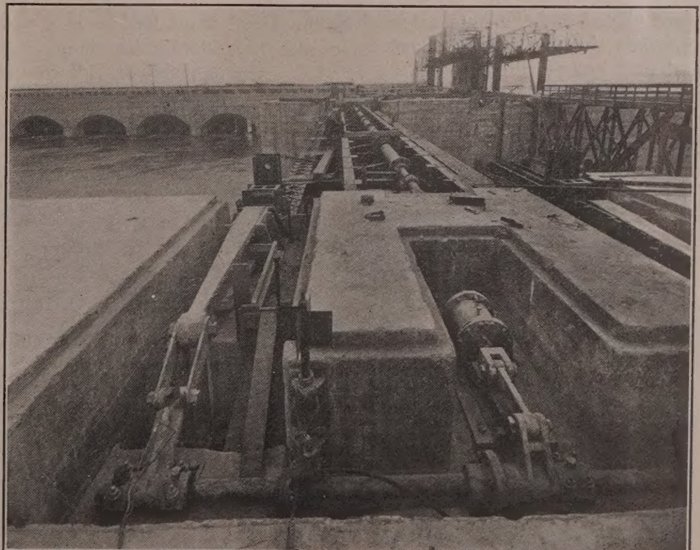
Turntable for Operation of Mitering Gates



Lock Intake Valves and Operators' House



Downstream View of Mitering Gate, Showing Frame



Operating Mechanism, with Semaphore for Guard Gate more than one-half the circumference. The connecting rod, or operating strut, is provided with a double-acting spring to absorb shock from the engine or that due to the meeting of any obstruction of the gate when sustaining water pressure. One-inch movement each way from normal is controlled by this spring. Due to the angles and leverage, this is equivalent to a 4-in. travel at the mitering face, so that an 8-in. block of wood could be caught between the mitering faces and do no damage.

Over the miter post on one leaf is a pneumatic miter forcing machine which seizes a post on the opposite leaf in a pair of giant jaws and lines the faces against each other.

The turntable is equipped with an electrical contact so wired that successive positions of the gate are indicated by electric lights on the control board in the operator's house at the far end of the lock. Five inches beyond the dead center a four-way limit cock, the handle of which is guided by a cam on the wheel, reverses the engine by means of an air cylinder controlling the reverse lever. The wheel will continue to oscillate back and forth 5 in. each side of the dead center until the operator shuts off the main air supply. At this point the gate movement is so small that the miter-forcing machine can operate with the turntable stopped anywhere inside of the 5-in. limit.

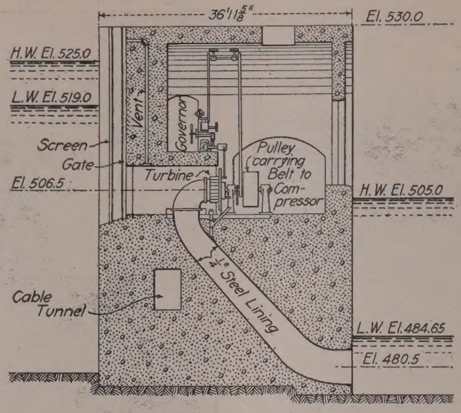
Setting the cast-iron reaction blocks in concrete was accomplished by erecting a temporary structural-steel post in exact position, bolting the blocks to this post and then placing the concrete.

Anchorages at the top of the quoin post comprise two sets of double 2 x 8-in. eyebars. One is shown in the drawing in elevation and the other is at right angles to this.

All steelwork for both floating and mitering gates was fabricated by the Chicago Bridge & Iron Works.

Fitting the Miter Sill

Not until the gate had been completed and swung into closed position was the 12 x 12-in. oak miter sill fitted. First, the oak piece was slipped over the horizontal bolt connections, leaving 3 in. for fitting against the back and bottom surfaces. Second, wooden struts were applied against the gate with a force equal to 150 tons uniformly distributed over the bottom of each leaf. Third, the oak pieces were forced tight against the cast-steel contact castings and held there by wooden wedges until the concrete deposited around the sill had set. Fourth, vertical bolt holes were bored through the sill and drilled into the concrete, fox bolts were placed and the nuts screwed tight. For renewals the vertical bolts are to be cut off and new holes drilled.



Cross-Section of Lock Power House

To make sure that the holding-down bolts grip the bed rock after the concrete forming the sill had set, the 2-in. gas pipes around the bolts were not grouted until the bolts had been subjected to an initial stress of 15,000 lb., accomplished by a 150-lb. pull at the end of a 3½-ft. wrench.

Lock Power House

Located in the wall connecting the upper end of the lock and the lower end of the power house are two 200-hp S. Morgan Smith single-runner Francis turbines, which are belt-connected to Ingersoll-Rand 13 x 16-in. air compressors, and are controlled by Lombard governors. Each unit alone has sufficient capacity to operate the lock and drydock machinery and drive the equipment housed on the lock grounds. From the engine room stairways lead to tunnels carrying the air piping and electric cables under the lock and drydock gates.

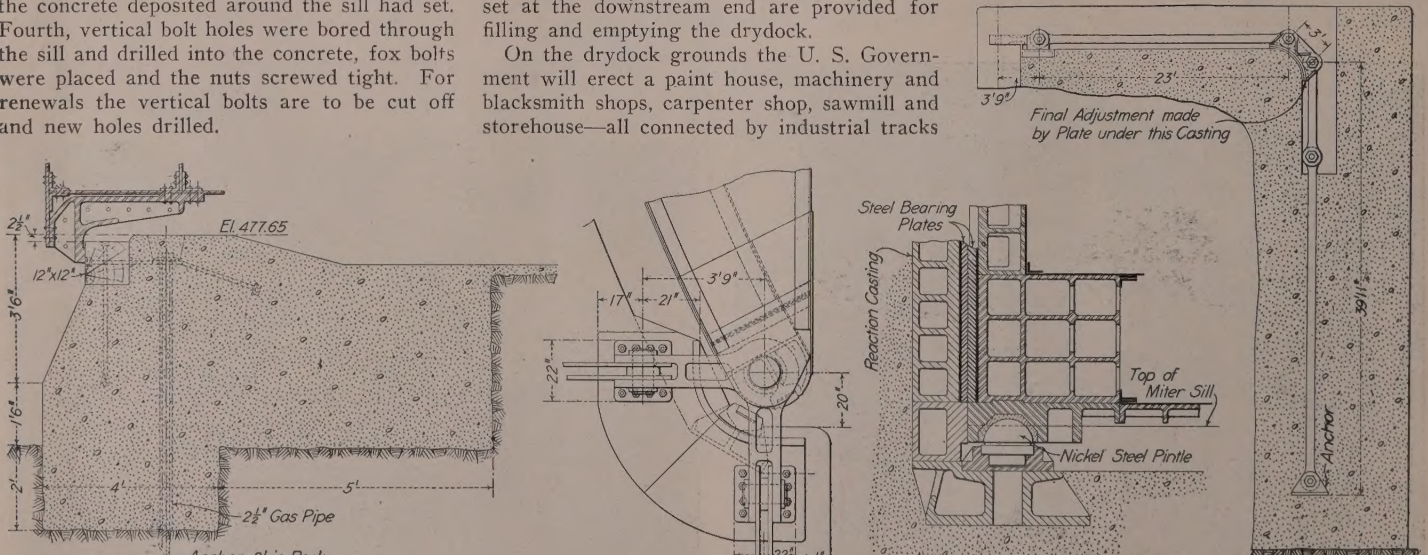
Built last is the 150 x 463-ft. drydock, as it is located over the former lock, Government headquarters and reservation. The site is now being filled in to conform to the general drawing. On the river side is the lock wall, while on the downstream side a concrete gravity wall extends from the lower end of the lock to the embankment of the lock grounds and on the upper side is an extension of the concrete gravity sea wall along the railroad embankment. A switch track laid on top of this latter wall leads over the gates for the drydock and lock to the power house. Two hand-operated butterfly valves, 6 ft. in diameter at the upstream end and a similar set at the downstream end are provided for filling and emptying the drydock.

On the drydock grounds the U. S. Government will erect a paint house, machinery and blacksmith shops, carpenter shop, sawmill and storehouse—all connected by industrial tracks as well as by standard-gage switches to the railroad. Power to operate the machinery located in these buildings, at the lock and at the drydock is to be compressed air.

No part of this work has been done by the contract system, the construction forces being directed by the chief engineer. The entire work has been built under the personal supervision of Mr. Hugh L. Cooper, M. Am. Soc. C. E., of New York, chief engineer of the Mississippi River Power Company, who resides at Keokuk during the construction period. Mr. B. H. Parsons, of New York, M. Am. Soc. C. E., is the mechanical engineer. The construction has been carried on in two separate and distinct organizations. The Illinois division, under Mr. Dexter P. Cooper, directed the building of the dam; the Iowa division had charge of the power house and lock. Mr. H. T. Herrick was at the head of the Iowa division until his death on May 26.

Water Consumption in Boston

The daily average quantity of water consumed in the eighteen municipalities, including Boston and nearby towns, supplied from the Metropolitan waterworks during the year 1912, as measured by Venturi meters, was 116,230,700 gal., equivalent to 107 gal. per capita in the district supplied. The daily average consumption was 6,235,900 gal. more than during the previous year. Of this increase about 1,000,000 gal. per day was due to the addition of the former town of Hyde Park, with a population of 16,260, but the greater part of the increase was caused by the use and waste of water during the extremely cold weather in January, February and March. During the extremely cold weather in those three months it is estimated that the quantity used to prevent freezing of pipes was 1,106,882,000 gal., equivalent to 3,024,000 gal. per day for the entire year. In all the cities and towns of the Metropolitan water district, with the exception of the town of Revere, the number of services now metered is in excess of the provisions of the Acts of 1907, which require at least 5 per cent of the number not metered on Dec. 31, 1907, to be metered each year thereafter. At the end of 1912, 51.77 per cent of all the services in use in the Metropolitan district were metered, and 77.50 per cent of the services in the cities and towns outside of Boston.



Section of Sill — Plan of Upper Hinge — Section through Lower Hinge — Anchor for Miter Gate

Details of Miter Sill Contact, Upper and Lower Hinges, and Anchor for Mitering Lock Gates

POWERFUL INFLUENCE OF BASIC PIGMENTS IN PROTECTING METALS FROM CORROSION

Supplement to Engineering Record, July 26, 1913,
accompanying article on page 93.

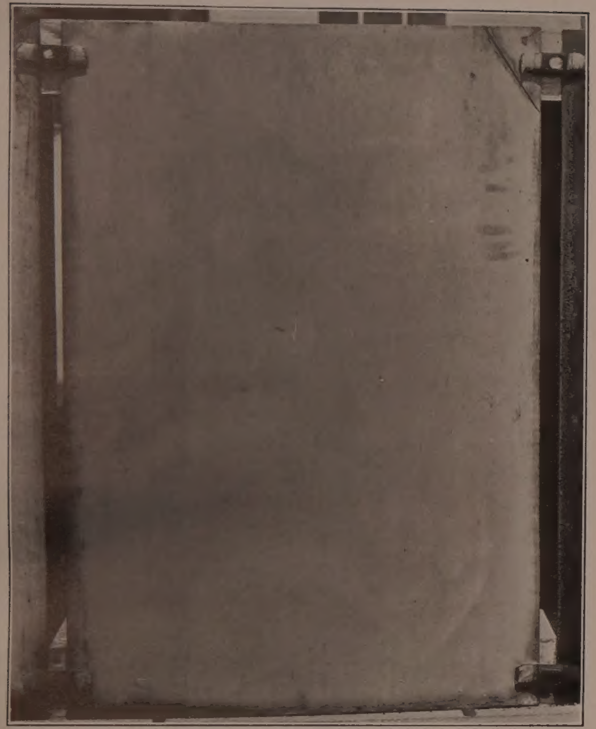


Fig. 1—High Percentage Basic Lead Pigment

Panel 11C5—Showing Excellent Condition of Paint. Formula: 19 Lb. Sublimed Blue Lead to 1 Gal. Linseed Oil

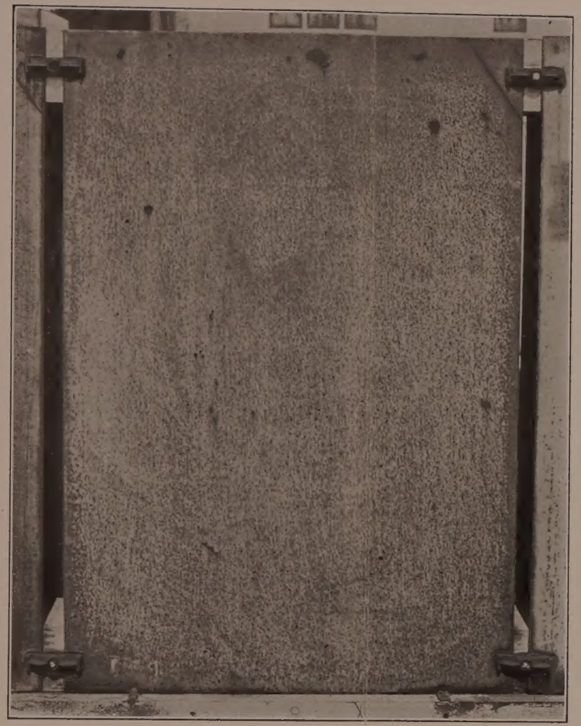


Fig. 2—Paint Containing Neutral Lead Pigment

Panel 1C9—Showing Whitened and Somewhat Pitted Surface. Formula: 27 Lb. Orange Mineral (Pure Red Lead) to 1 Gal. Linseed Oil

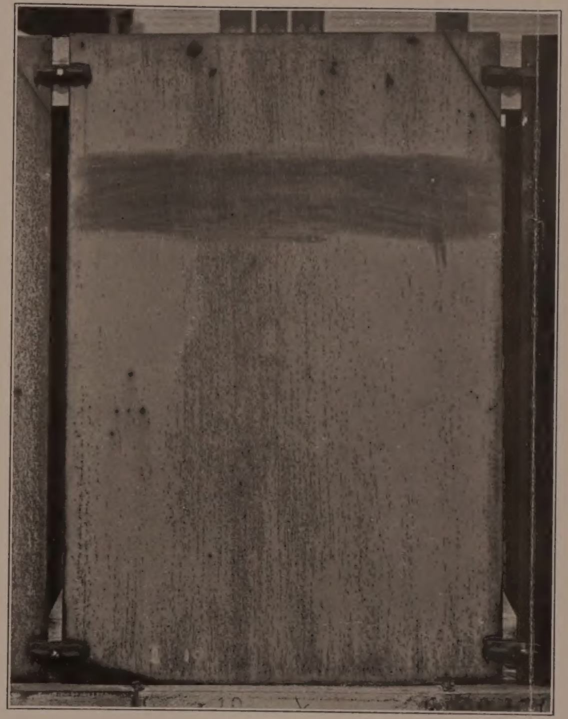


Fig. 3—Less Neutral but Highly Oxidized Lead Pigment

Panel 1C10—Showing Whitened and Slightly Pitted Surface. Formula: 26 Lb. Red Lead to 1 Gal. Linseed Oil

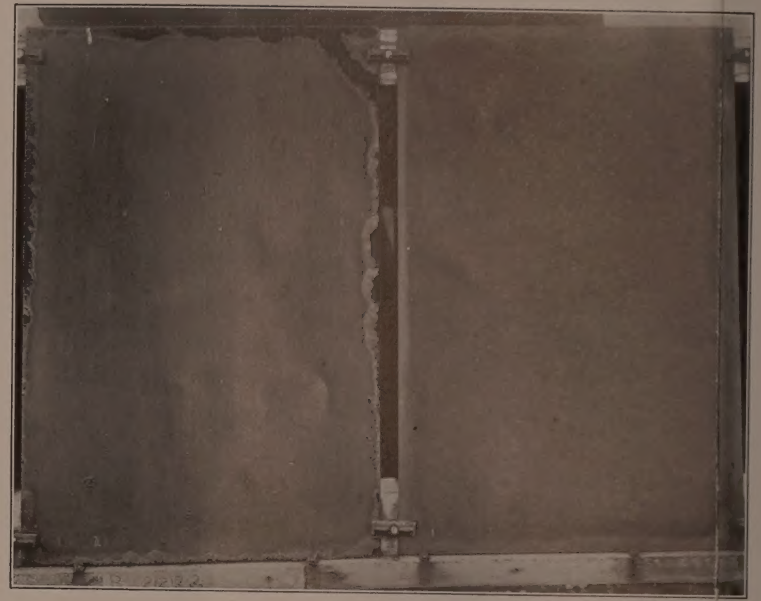


Fig. 4—Paint Applied to Black and to Cleaned Metal

Panels 1B2222 and 2C2222—Black Panel on Left; Cleaned (Pickled) Panel on Right. Paint in Excellent Condition

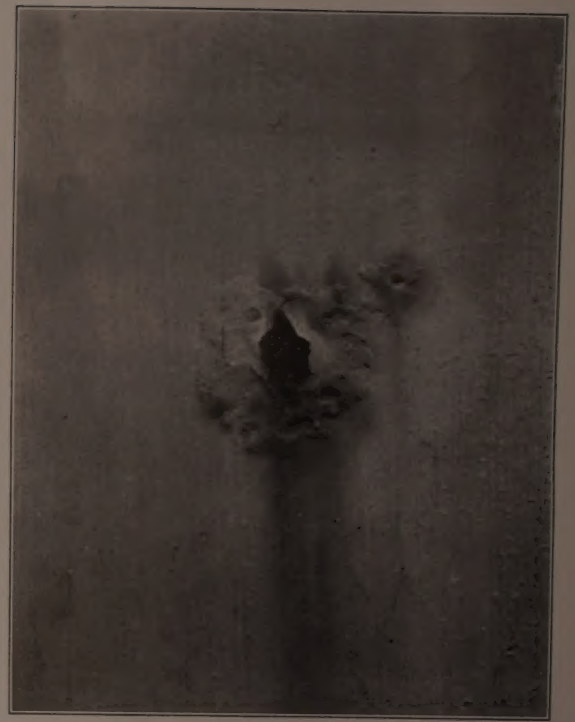


Fig. 5—Paint Applied to Black Metal Surface

Detail of Panel 1B444—Showing Crater-Like Formation of Film, Distended by Rusted Metal

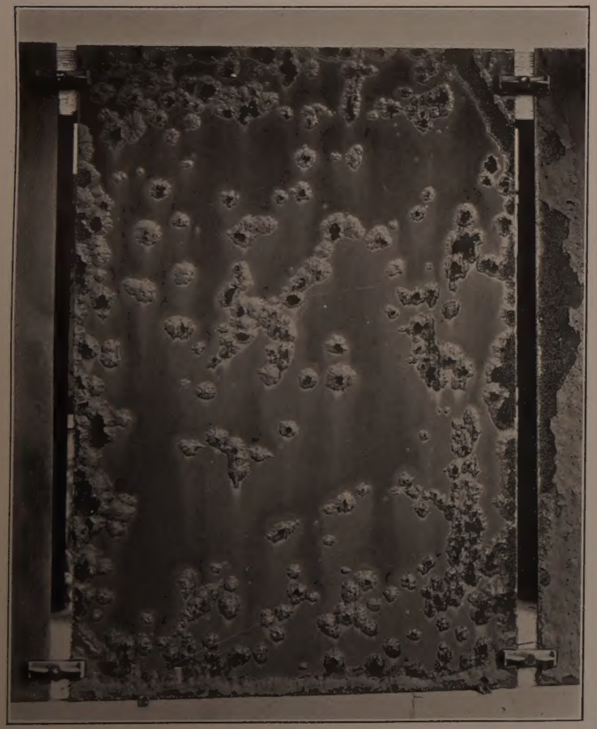


Fig. 6—Paint Applied to Black Metal Surface

Panel 1B3333—Pronounced Pitting and Crater-Like Eruptions. Paint Contains Gas Carbon Black, Zinc Oxide and Silica

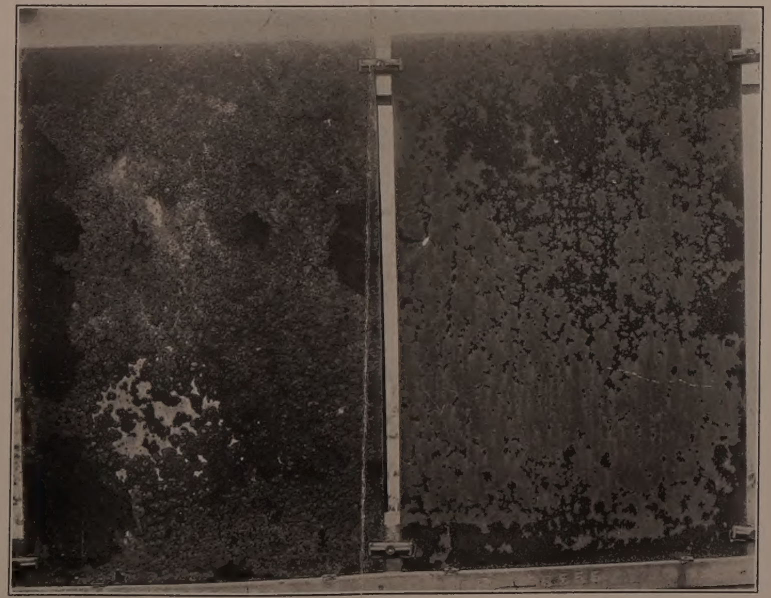


Fig. 7—Commercial Graphite and Coal-Tar Paints

Panel 2B6666 and 2B555—Graphite Paint on Left; Coal-Tar Paint on Right

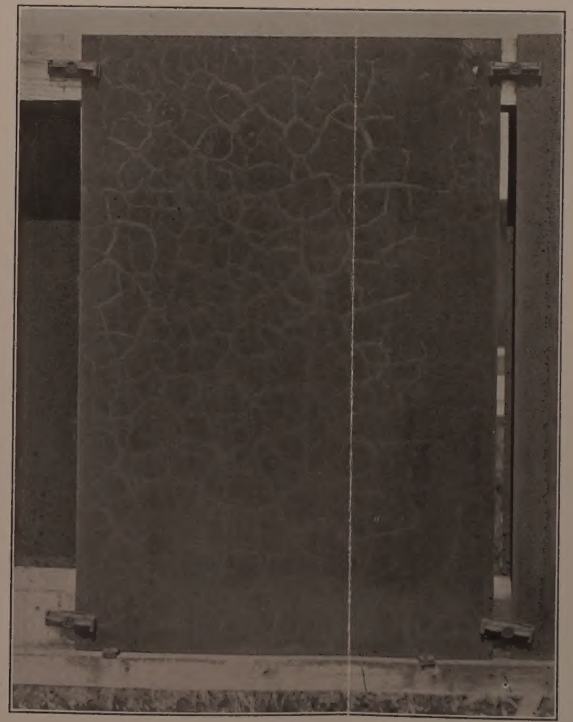


Fig. 8—Coal-Tar Paint over Red Lead

Panel 5555—Two Coats of Tar Paint over One Priming Coat of Red Lead. Pronounced Alligatoring, Due to Disintegrating Action of Sun on the Coal Tar

Fig. 9—Varnish Paint Film on Black Metal

Detail of Panel 2B3000—Showing Alligatoring

Fig. 10—Pin-Like Eruptions on Iron Oxide Paints

Panel 11C14—Formula: 9½ Lb. Venetian Red to 1 Gal. Linseed Oil

Powerful Influence of Basic Pigments in Protecting Metals from Corrosion

By Henry A. Gardner, Assistant Director, Institute of Industrial Research, Washington, D. C.

(Accompanied by Folding Insert Plate)

In a recent article on the subject of metal paints ("Primers for Metals," Bulletin 37, scientific section, Paint Manufacturers' Association of the United States) the writer called attention to the remarkable rust-preventing properties of litharge (monoxide of lead), a pigment which gave even more pronounced inhibitive results than the chromate pigments when placed in water in contact with iron plates. The power of litharge to keep iron absolutely free from rust was attributed to the highly basic nature of the pigment, basic substances when present in sufficient concentration being well recognized as powerful inhibitors of corrosion. Attention was called, however, to the impracticability of litharge as the pigment base for an oil paint on account of the rapid mass hardening that occurs when litharge is mixed with linseed oil. The cause of such hardening phenomena is easy to understand when the readily saponifiable nature of the drying oils is taken into account. The product of reaction between litharge and linseed oil is lead linoleate, a powerful paint drier, which has remarkable oxygen-carrying properties.

The writer, in the article previously referred to, in commenting on the litharge content of red lead, brought out several points which are pertinent to the present discussion, as follows:

Litharge Content of Red Lead

"Although red lead is chemically termed the tetroxide of lead, a combination of litharge (the yellow monoxide) and storage-battery lead (the brown dioxide), there is often formed, according to the process used, a product which contains varying percentages of free litharge or uncombined oxide. It is this percentage of litharge which makes some red leads more apt to body and harden in oil after long standing than other types of red lead.

"Orange mineral, a type of red lead made by roasting white lead, is practically pure-lead tetroxide and for this reason red-lead paints made from orange mineral do not body or harden and may be kept for months in a smooth condition. On account of this fact red-lead manufacturers have endeavored to produce red leads with a minimum litharge content by the old method of roasting pig lead, and some manufacturers have marketed a product which contains as high as 98 per cent of pure red lead and less than 2 per cent of litharge.

"Although such red lead is preferable for making red-lead paints which are to be packed for some time before use, it is not as highly inhibitive in its protective effect as those red leads which contain high percentages of litharge.

"One feature of this question, however, which has not received sufficient investigation is that relating to the physical structure of the pigment particles. The writer is of the belief that a pigment containing as high as 15 per cent of litharge would be free from the objection of excessive action upon oil if the pigment particles were of the correct physical structure. Such a pigment would undoubtedly be preferable on account of its increased inhibitive properties."

It is of interest to record that paint pigments are now available which contain a very high percentage of litharge in such physical condition as to be practically free from action upon linseed oil and yet possessed of the normal inhibitive character to be expected of the litharge content. The pigments referred to are those which are produced by the sublimation of lead and zinc ores, among which may be mentioned basic sulphate-white lead and sublimed-blue lead. The latter material consists approximately of 65 parts of lead sulphate and 35 parts of lead oxide, the components being chemically and physically combined in the form of an amorphous pigment substance of great fineness. The presence of small percentages of carbon and lead sulphide as natural impurities gives to this pigment a pleasing steel-gray color. Although the high percentage of litharge in this product, if uncombined, would be sufficient to cause the immediate hardening of a linseed-oil paint made therefrom, experiments have shown that this pigment is practically free from reaction with saponifiable oils. That this pigment is highly inhibitive and most durable when mixed with linseed oil and spread upon iron plates has been demonstrated in exposure tests placed by the writer at Atlantic City five years ago under the supervision of the American Society for Testing Materials. Attention is called to the excellent condition of the pigment, as shown in Fig. 1 (see folding insert plate).

Factor Affecting Inhibitive Value

That the degree of basicity of any pigment is to a large extent responsible for its good behavior when applied as an oil paint to a metal surface is further substantiated in the tests referred to by the results obtained with the lead-chromate pigments applied on panels 34 and 36. Normal or neutral lead chromate (test 36) gave only fair service. On the other hand, basic chromate of lead (test 34), a lead-chromate pigment containing a considerable percentage of litharge in chemical combination with normal-lead chromate, was found to be the most highly inhibitive protective paint in the tests. After five years' exposure its rating is still practically 100 per cent, as recorded by the official inspectors.

A chromate pigment, to be inhibitive, must be either slightly water soluble or basic. Zinc chromate is a good example of a slightly water-soluble chromate pigment. In the presence of water it is subject to ionization, thus rendering available its chromic acid content, which has the effect of preventing the solution pressure of iron. Basic chromate of lead is a good example of a chromate pigment which is highly inhibitive on account of its basic nature. On account of the insoluble and neutral nature of normal lead chromate this material would not be expected to fulfil the requirements of an inhibitive-chromate pigment.

Value of Zinc Oxide

Zinc oxide is another basic pigment which has proved highly valuable as a constituent of metallic paint. In physical combination with lead sulphate (in about equal parts), as it occurs in zinc lead, this pigment has shown the pronounced inhibitive effects of pigment basicity. Zinc oxide fortunately is a pigment which of itself may be ground in linseed oil, of normal acid value, and show little tendency toward hardening. In this form, therefore, it is coming into use as an inhibitive base pigment to admix with iron-oxide roofing paints, to which it adds considerable merit. In a previous article this subject was discussed as follows:

"The greatly increased protection which was afforded the iron plates by the addition of zinc oxide is of practical interest to the painter, inasmuch as zinc oxide in oil is a common adjunct to every paintshop, and its addition to the widely used and popular iron oxide, or so-called metallic paints, is a simple matter. Such addition, moreover, produces a paint which has great spreading power and other desirable properties. It is also of interest to note the increased inhibitive effect that is obtained by the addition of zinc oxide to corroded white lead, mixtures which could be used for the production of white or shaded metallic paints. It may be pertinent to record at this point that such mixtures have proved more durable in field tests than either single pigment."

Value of "Pure" Paint

In a recent article, entitled "Paint Efficiency and Paint Purity," which appeared in the "Iron Age" for Feb. 13, 1913, Mr. George Auchy states that the paint trade is discovering that "the purer the paint the poorer." Assuming that the word "pure" may be applied to such a substance as paint, there can be no question but what Mr. Auchy's theory holds good in many instances. That the purity of a truly stimulative pigment has much to do with its rust-producing properties there is much evidence to show. Pure graphite, pure carbon black and pure lampblack, ground in oil and applied to steel plates in the Atlantic City tests, developed their rust-exciting tendencies in a very short time. Tests simultaneously made, with the same pigments admixed with large percentages of neutral inert pigments such as barium sulphate and silica, prove the value of these so-called paint extenders in nullifying the corrosive action of the black-carbon pigments and in strengthening their films.

That the theory "the purer the paint the poorer" would not always apply where a really inhibitive paint is concerned is the writer's belief. Paints made entirely of basic chromate of lead, pure sublimed blue lead or pure zinc chromate, ground in the proper amount of linseed oil, will outlast paints made of only a small percentage of the same pigments admixed with a large percentage of barium sulphate or china clay. However, there may be a critical point in the admixture of the inhibitive pigments with the inert pigments where added percentages of the inhibitive pigments cease to add proportionately to the value of the mixture. This point, however, has not been determined by practical tests with all of the pigments, although considerable laboratory investigations on the subject have been made.

Basicity in the Light of Results of Tests

As further proof of the effect of basicity upon the rust-preventing properties of pigments attention is called to plates 9 and 10 at the end of a five years' test, depicting the condition of two grades of red lead, one of which has been given the trade name of orange mineral. (See Figs. 2 and 3.) The latter type of red lead is produced by the oxidation of off-color white lead or white-lead tailings. In its highly oxidized condition it is practically 100 per cent red lead (tetroxide of lead), with no appreciable percentage of litharge. The condition of the paint made from this pigment (see Fig. 2) is far from satisfactory. The other type of red lead contains an appreciable percentage of litharge and, as will be seen from the photographs, plate 10 is in much better condition than plate 9. The latter test would, no doubt, have been in still better condition had the red lead contained a larger percentage of litharge. The manufacturer of red lead, however, has been striving to produce a product which will answer specifications which are often ill advised, the purchaser having the misconception that the purest red lead—one containing the highest percentage of lead tetroxide—would be the best.

In the endeavor to meet such specifications some manufacturers have made use of artificial oxidizing agents, such as potassium nitrate, in conjunction with the furnacing of the pigment. The red lead resulting from such treatment, although containing often as high as 98 per cent lead tetroxide, is liable to contain a small percentage (0.1 to 0.5 per cent) of soda or nitrate salts. These may be extremely active in promoting rust, and the small pinhole rust spots on panel 10 may be due to this very action.

A Proposed Specification

The question that now remains for decision is: Of what should a red lead consist in order to be thoroughly inhibitive? In the writer's opinion red lead answering the following specifications would be highly inhibitive and more acceptable than any other for general painting purposes:

Red lead (tetroxide of lead, Pb_3O_4)........	82-88 per cent
Litharge (monoxide of lead, PbO)..........	18-12 per cent

Less than 0.5 per cent total impurities such as copper, silica, iron, etc. Must be free from nitrate salts.

The red lead should be bright in color and of such fineness that 99.5 per cent should pass through a 200-mesh screen.

Such a red lead would be more generally available than one containing the higher percentage of lead tetroxide. The drying power of such red lead would be excellent, and if mixed with linseed oil just before application would prove a highly satisfactory paint. It is well to record at this point that those red leads which consist almost wholly of lead tetroxide are not good drying pigments. It is even necessary to add artificial driers to linseed-oil paints made from such pigments. Such paints, however, have the advantage of remaining soft even after standing in sealed packages for several months. This property of the high-percentage red leads has made them popular in the manufacture of ready-mixed pure red-lead paints. The service to be expected from such paints, however, would not be as great as the service attending the use of a prepared red-lead paint made from red lead containing litharge in considerable proportion, such, for instance, as that shown in the above specifications, mixed with equal parts by weight of an inert pigment such as silica, china clay or asbestine. Paints made from such a mixture would be practically free from hardening in a package for a considerable period of time. They would, moreover, be less expensive than 100 per cent pure red-lead paints. In inhibitive power, spreading capacity, and brushing properties they would be superior to paints made from 100 per cent pure red lead.

Influence of Carbon Paints, Portland Cement and Cyanamide Pigments

The action of the carbonic acid of the air in changing the surface of red lead to the white carbonate of lead is well shown in Fig. 3, where part of the plate has been washed to remove the whitened surface, disclosing the unacted-upon red lead beneath. This condition is rarely met with in practice on account of the custom of using other pigments as surfacers over red-lead paints for priming metal. Carbon black and lampblack are very popular for use as surfacers for red-lead paints, and for such use they give excellent results. In this connection it might be well to state that excellent results may be expected from most pigments which are basic in nature, if they are applied properly to a metal plate and then surfaced with a paint containing a carbon pigment, such as lampblack, carbon black or graphite. There are included in the Atlantic City tests several panels which were originally painted with three coats of ordinary whiting (calcium carbonate) ground in linseed oil. On the lower left-hand corner of these panels were placed numbers with lampblack paint. The basic nature of the calcium-carbonate pigment protected the metal from corrosion for a considerable period of time. The great chalking tendency, however, of the whiting caused the removal of the paint within eighteen months, except in those spots which had been coated with lampblack numbers. In such places perfect condition of the paint film is shown. This result further strengthens the writer's good opinion of basic pigments as primers of metal.

Ordinary Portland cement, as well as furnace slags, has been used with some success as pigment for metal paints. The development of basic lime compounds which takes place when moisture comes in contact with such pigments, if in sufficient concentration, protects metal from corrosion. Paints of such nature have appeared on the market from time to time and have in some cases proved quite useful.

Cyanamide pigments have recently been used with successful results by Fulloni and by Liebreich. The former uses a large percentage of the cyanamide pigment, while the latter depends on a small percentage for the ultimate results. When water comes in contact with a cyanamide pigment highly basic compounds are developed, which protect metal from corrosion.

Influence of Mill Scale

The question as to whether painting done over metals surfaced with mill scale would be as efficient as painting done over metals previously cleaned from mill scale through the use of the sandblast or by pickling has been discussed at length by various authorities. In some instances, such as in the case of a large steel-bridge structure, the cleaning of the metal before painting is often impracticable. Excellent results have been recorded of painting done on such types of work, directly over the mill scale. For smaller work, however, wherever the removal of the mill scale is practicable, the expense of cleaning will be justified by the good results obtained. Fig. 4 is interesting in this connection. The formula of the paint used is:

Formula of Paint

	Pigment formula	Total formula
Iron oxide	50	26.67
Zinc chromate	15.63	8.33
Calcium carbonate	3.75	1.67
Silica	30.62	16.66
Japan drier	.....	4.54
Linseed oil	.....	42.13

A pinhole in a sheet of tin plate may lead to the destruction of the plate. A pinhole in a paint film or a defect in the metal surface may lead to serious results if the pigment is not inhibitive. This is shown in Fig. 5, where there is seen a large crater-like eruption on one spot of a painted panel, which otherwise is in good condition. The admission of moisture through an abrasion in the film may be primarily responsible for the appearance of the surrounding paint film, with the formation of a cup which collected and retained sufficient water to start the active formation of rust. The increasing amount of rust expanded the size of the film cup, gradually filling it with a soft, porous, water-retaining mass of iron-oxide pigment. If the pigments in a paint film are thoroughly inhibitive, pinholes or scratches do not constitute a serious menace, nor do they lead to the results shown in the photograph. The moisture which deposits upon the abraded surface has little or no effect when in the presence of a thoroughly inhibitive pigment. This condition, however, might not hold true in certain cases. Some sheets of black metal have upon their surface a type of mill scale which is evidently not of a continuous nature. The electro-negative nature of the mill scale would tend to force into solution any exposed area of iron. Development of gaseous hydrogen beneath the paint film at such spots would account for the formation of blisters, such, for instance, as are shown in Fig. 6.

Miscellaneous Paint Materials

By-product tars from coke ovens, gasworks and other sources have formed the base of a great many paints sold for the protection of metal. These paints make very good coverings for metal exposed to acid fumes within buildings, but do not have the property of withstanding exterior exposure. The action of the sun is most powerful in breaking them up. Figs. 7 and 8 are interesting in this connection.

It has been thought that greater durability might be expected of a paint if its linseed-oil content were replaced with varnish containing costly resins such as kauri and copal. As a matter of actual test, however, varnish paints for metal have never proved very satisfactory. The crazing of the varnish is responsible for the early decay of such paints. This effect is shown in Fig. 9.

Iron oxide might also be classed as a basic pigment. If of good quality, it gives very fair results on metal surfaces. When admixed with calcium sulphate in the form of venetian red, it is less satisfactory than when used in its purer state. (See Fig. 10.) Black precipitated oxide of iron is, on account of its highly basic nature, a pigment of great value in the manufacture of metal paints. Black paints made with this pigment have outlasted all the other black paints exposed at Atlantic City. Its use should rapidly increase, now that its merit is established. In fineness and hiding power it is superior to all other forms of iron oxide.

A New Water Ordinance at Los Angeles, a city which is 100 per cent metered, contains provisions limiting the number of services on pipes of specified size. Only one service connection is allowed upon a ¾-in. pipe, having a pressure of less than 20 lb., two services upon a ¾-in. pipe with pressure between 20 and 60 lb., and three services upon a ¾-in. pipe with over 60 lb. pressure. A 1-in. pipe may be allowed twice the number of service connections as a ¾-in. pipe at the same pressure. A 1½-in. pipe may serve twice the number as a 1-in. and a 2-in. twice as many as a 1½-in. pipe. The department has printed a booklet listing the cost of service connections. The charges include the service connection complete, the meter set in place and an adequate meter box with metal cover. The regulations provide that a water main need not be extended more than 100 ft. in a street for any one applicant. Further extensions may be made by the Water Department if paid for by the applicant. All new service connections must be fitted with a stop-cock, placed inside the line of the street curb, a meter, meter-box, and cast-iron cover.

Astoria Tunnel Holed Through

Completion of Bore to Carry Gas Mains under the East River, New York

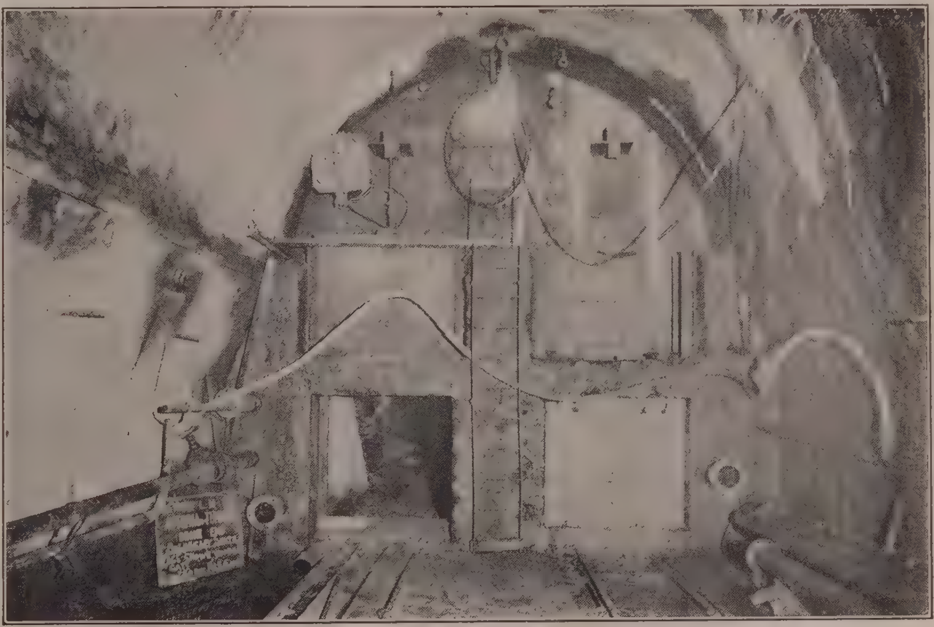
The holing-through of the Astoria tunnel under the East River, New York, on the afternoon of July 17 marks the final stage of the work which the Consolidated Gas Company undertook on Sept. 12, 1910, to provide a direct route for the delivery of gas from its plant at Astoria, Long Island, to Port Morris in the borough of The Bronx on the opposite side of the river. Surrounded by a group of half a hundred guests, who had been invited to witness the blast which would open up a clear passageway from one side of the river to the other, Mr. George B. Cortelyou, president, and Mr. W. H. Bradley, chief engineer of the company, closed a pair of silver-mounted switches completing the electric circuit which detonated charges of dynamite in the 3-ft. rock wall forming the only barrier between the Bronx and Astoria ends of the bore. It took two shots to clear an opening large enough for the members of the party to crawl through, and one by one, in dripping coats and thigh boots, they emerged from the ragged-edged aperture in the rock, 250 ft. or so below the surface of the East River, and splashed onward in single file to the Bronx shaft, completing the first subaqueous trip from Astoria to New York.

Alignment Checks Closely

Shortly after the smoke had cleared away Mr. W. Cullen Morris, who had been in charge of the tunnel as engineer of construction for the gas company, announced that the alignment between the two ends of the bore had checked within ¾ in. and the grade within ⅜ in. After the rubber-clad throng had been hoisted to the surface a levee was held at the company's field office, toasts were drunk and congratulations extended to Mr. Bradley, Mr. Morris, Messrs. Jacobs & Davies, who served as consulting tunnel engineers, and Engineers George E. Woods, Vivian Messiter and Harold Carpenter, all members of the engineering staff which had striven against unusual difficulties in the form of excessive leakage and a 400-ft. stretch of treacherous ground filled with mud seams, until the rumble of the last blast broke the strain of almost three years' persistent effort in the designing room and in the "hole."

Tunnel Section

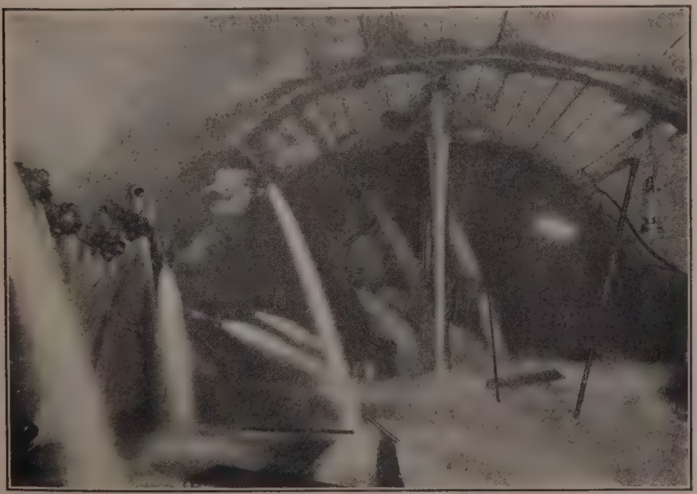
The Astoria tunnel has a concrete-lined section in the form of a letter D, the flat side forming the floor. The material through which it is driven is mostly gneiss and limestone. The bore has a width of 19 ft. 9 in. and a height of 21 ft. and will carry two 6-ft. gas mains, with room for two others to be installed as future needs may demand. The concrete lining varies in thickness from 18 to 36 in. and in some places is reinforced with steel rods. The tunnel is 4662 ft. long and was driven from two vertical shafts; the Astoria shaft is 34 ft. 6 in. in diameter and 276 ft. 9 in. deep, while the Bronx shaft has a diameter of 26 ft. and a depth of 233 ft. The mean depth of the tunnel floor below the river surface is 246 ft. Working at such a depth under compressed air would have necessitated pressures far in excess of what was considered the safe limit for the workmen, so that all the tunneling was carried on in open air, although at times the leakage was as high as 6000 gal. per minute.


Emergency Bulkhead, Showing Wooden Door and Man Lock at Top

Fish as a Tunnel By-Product

The gas company is responsible for the story that where large volumes of water were encountered at one point in the tunnel a great number of fish were carried from the river into the bore. For several days the workmen caught these fish and took them home for dinner—at least that is the way the tale runs.

After the headings had been turned the tunneling proceeded without difficulty for 750 ft. from the New York side, when a large inflow of water was encountered. Work from this heading was suspended and efforts concentrated on the heading from Astoria, which was advanced 3500 ft., or to within about 400 ft. of the Bronx heading, when bad ground and leakage again began to cause trouble. The work remaining to be done was in a zone of contact between the gneiss and limestone strata. The rock formation was greatly disturbed; there were fissures of disintegrated material, bearing water under full head, and in some places large, empty pockets were uncovered. Pilot holes had to be drilled in advance of the heading; these were plugged with valve pipes and where the leakage was high were grouted under a pressure of 500 lb. per square inch. Concrete bulkheads also were built at intervals across the tunnel sections and were fitted with quick-closing gates at the bottom and man locks at the top to prevent the flooding out of the whole tube and to allow the workers to escape in the event of a sudden inrush of water. Cast-iron ring lining was resorted to in this section. The 400-ft.


Leakage Through Grout Pipes in Arch

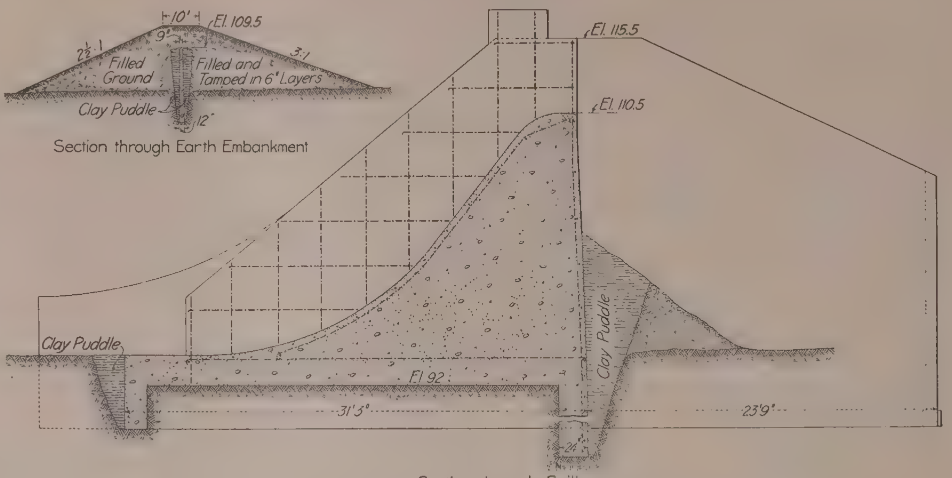
Completed Section of the Astoria Tunnel

stretch of bad ground delayed the completion of the tunnel more than a year and added greatly to its cost.

In putting in the concrete lining the ground water was drained away by pipes passing through the forms. These pipes are now being used to carry grout into the open spaces behind the lining and thereby cut off the leakage.

There yet remains to be completed a short section of concrete lining at the point where the headings were holed through. When this is finished the two 6-ft. gas mains will be laid within the bore and the Astoria plant will then be linked up with the gas-service mains supplying the borough of The Bronx across the river.

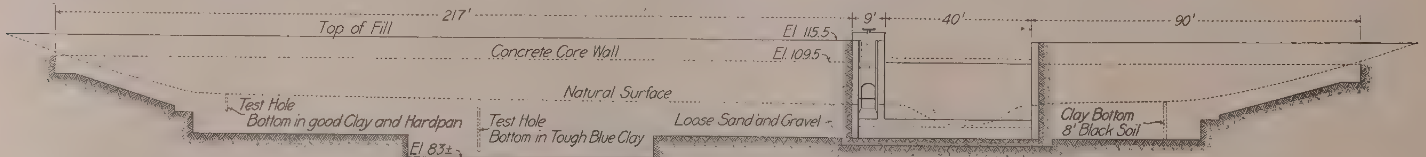
Waterworks Extensions at Pana



Sections Through Earth Embankment and Spillway

Replacing an outgrown, hard well-water supply with a surface water at Pana, Ill., required the construction of a new power house on a siding in town, a dam on a creek 3 miles away, a pipe and a transmission line between the two, and a rapid-filter plant having a capacity of 1,000,000 gal. in twenty-four hours. Water is pumped from the reservoir, through the pipe line, to the filters by a motor-driven centrifugal pump. From the clear well under the filters it is repumped directly to the mains by steam pumps. The following notes are taken from a paper presented to the Illinois Water-Supply Association by Mr. A. C. Stanfield, city engineer.

In the 35 x 50-ft. power plant are two 100-hp boilers, one 50-kva generator and two compound pumps delivering 500,000 gal. per day when operating against 75 lb. pressure.

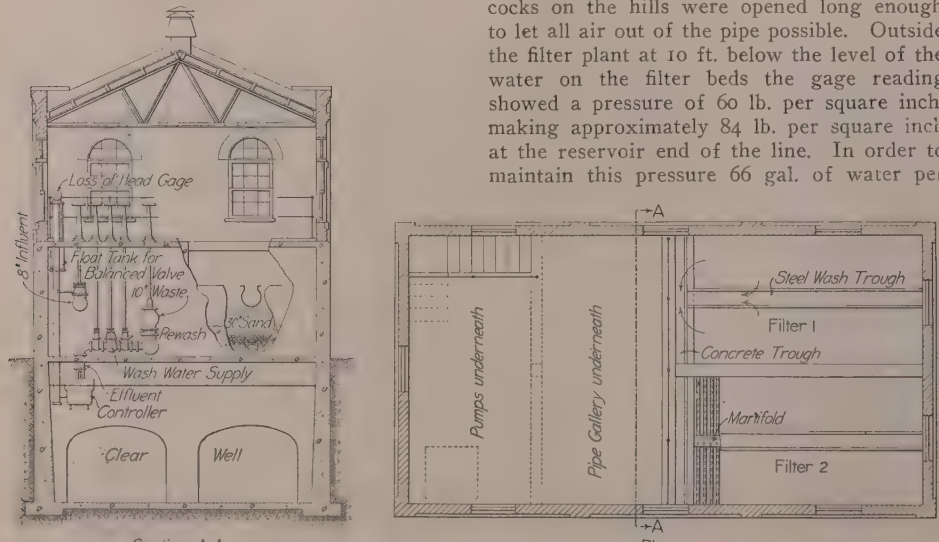

217'
Top of Fill
El 115.5
9'
40'
90'
Concrete Core Wall
El. 109.5
Natural Surface
Test Hole Bottom in good Clay and Hardpan
Test Hole Bottom in Tough Blue Clay
Loose Sand and Gravel
Clay Bottom 8' Black Soil
El 83±

Elevation of Dam, Showing Character of Material Found in Test Holes

FILTER PLANT

The filter plant consists of a two-story building, 23 x 42 ft. in plan, over a 60,000-gal. clear well under the whole structure. On the first floor are two 10 x 18-ft. filter units having a collector system of the American water-softener type. There are 850 strainers in each bed, over which there are 12 in. of ¼-in. gravel supporting 30 in. of sand. A single steel wash trough empties into a concrete gutter, which also removes soiled wash water near the front of the filter. The pipe gallery is in the center of the building, with the wash water pumps and chemical feed apparatus at the opposite end from the filters.

Some difficulty has been experienced with filter sand, according to Mr. Stanfield. Sand from nearby creek beds was used originally, but was found to have too high a uniformity coefficient and to contain so much fine material that the washing was excessive. Recently Red Wing sand has been purchased. The plant is not thoroughly successful, Mr. Stanfield stated, and will not be satisfactory until settling basins are installed; but at the time the system was planned it was realized that the bond issue could not be made sufficient to permit an expenditure for settling basins, so their construction was deferred.



Section A-A

Plan

Plan and Cross-Section of Pana Filter Plant

Loss of head through the 14,500 ft. of 10-in. cast-iron pipe on which there are six quarter bends, when pumping at the rate of 580 gal. per minute, is 20 lb., or 3.2 ft. per 1000 ft. of pipe.

A final test was made of the entire length of line for leakage. Both ends being plugged, the whole line was filled with water. The air cocks on the hills were opened long enough to let all air out of the pipe possible. Outside the filter plant at 10 ft. below the level of the water on the filter beds the gage reading showed a pressure of 60 lb. per square inch, making approximately 84 lb. per square inch at the reservoir end of the line. In order to maintain this pressure 66 gal. of water per hour were pumped into the pipe by hand. This is equivalent to a leakage of 1.1 gal. per minute. When in operation the pressures, instead of being 60 lb. and 84 lb. at the ends of the line, are 4 lb. and 48 lb. respectively, or 0 lb. at the water level inside the filter building, so that the actual loss on the entire line when in operation is somewhat less than the amount shown by the test. The pipe was tested in sections before the trenches were refilled, and all leaking joints were recalked as fast as they appeared. Several cracked pipes were found in testing and were replaced by the contractor.

The reservoir was made by building an ordinary earth dam with a concrete corewall and a concrete spillway 40 ft. long, the earthwork being 5 ft. higher than the overflow line of the dam. The corewall is founded on a layer of shale 8 ft. below the bed of the creek. The depth of the water at the dam is 17 ft. above the old creek bed and 12 ft. above the general ground level. The water is backed up in the valley a mile, and its area when flowing over the spillway is 40 acres. The reservoir area was timber land, and was cleared by sawing off the trees 6 in. above the ground, at a cost of $32 per acre. The timber was mostly small oak trees. No bad tastes or odors worthy of mention were caused by the stumps, but the vegetation along the creek had a good growth before the reservoir could be allowed to fill up, and its presence in the water caused a disagreeable odor.

Mr. Arthur Giesler, consulting engineer, of Dayton, Ohio, designed the system and supervised its construction, Mr. Stanfield acting as resident engineer. Mr. O. T. Dunlap, of Edwardsville, Ill., had the contract for all the work except the two high-service pumps, which were installed by the John H. McGowan Company, of Cincinnati, and the one motor-driven centrifugal pump, which was supplied by the Platt Iron Works, of Dayton, Ohio. The plant was put into operation in May, 1912.

A TREE PLANTING MACHINE, for use to reforest old burned areas on the national forests, is being tested at the Utah Agricultural Experiment Station.

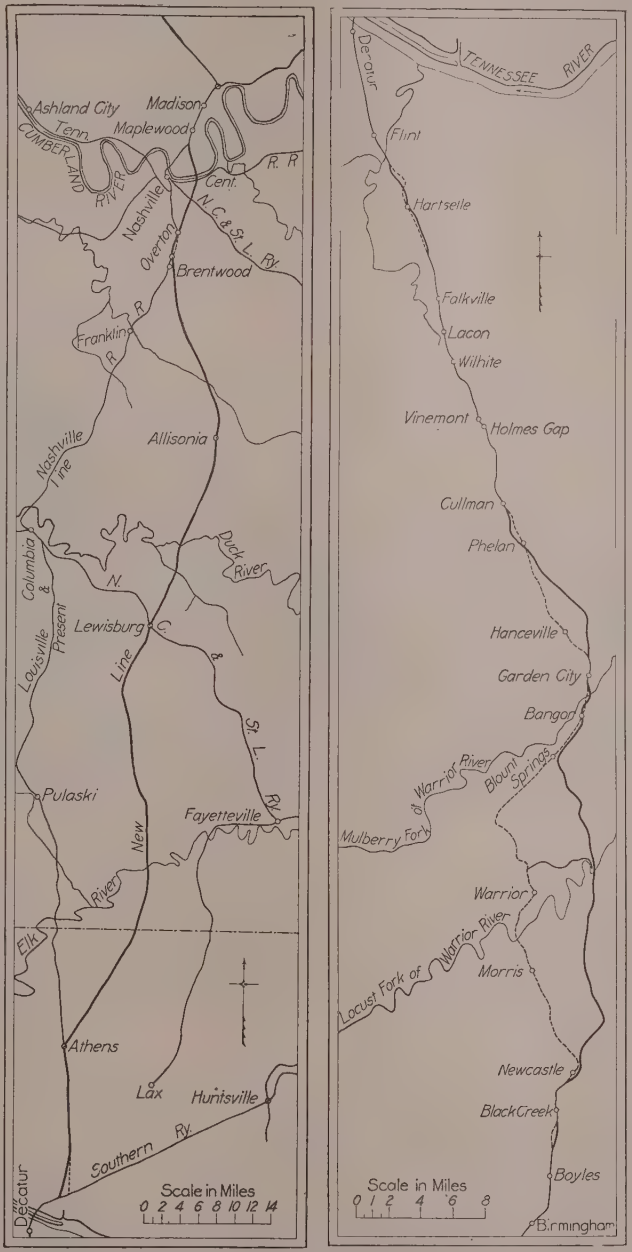
Relocation and Grade Reduction on the Louisville & Nashville Railroad

General Features of Improvements on the Main Line and in Eastern Kentucky

Two extensive and entirely independent projects are in course of construction on the Louisville & Nashville Railroad. One of these contemplates greatly increased operating capacity and efficiency on the most congested part of the main line between Cincinnati and New Orleans, extending over practically the entire 200 miles from Nashville, Tenn., to Birmingham, Ala. The other, extending southeast from Paris, Ky., is being undertaken to provide a more economical outlet for the coal fields in the eastern part of the state.

The main line, starting at Cincinnati, passes in a generally southerly direction through Louisville, Nashville, Birmingham, Montgomery and Mobile to New Orleans, a distance of about 920 miles. North of Nashville the line branches out, reaching St. Louis, Memphis and numerous other points. At Birmingham also it has numerous offshoots which afford a great many avenues for freight traffic. Between Nashville and Birmingham there was only the 200-mile single-track line to carry all the through north and south traffic. This line had curves as sharp as 6 deg. and grades of 1.25 per cent, uncompensated.

In concentrating the main-line expenditures on the improvement of this 200-mile section, ruling grades of 0.4 per cent were established in each direction for the operating division between Nashville and Decatur, Ala., and of 0.5 per cent in each direction between Decatur and Birmingham. In each section there is to be one short pusher grade, southbound, which could not easily be avoided. The maximum curvature was fixed at 4 deg.; and few of the curves are sharper than 3 deg. The ruling grades were made the same in each direction, for although the traffic in the two directions does not quite balance in a year, both the northbound and the southbound traffic are subject to frequent fluctuations, governed largely by the arrival of steamships at the various gulf ports.



Main-Line Changes from Nashville to Birmingham

EXTENT OF IMPROVEMENTS

The main-line improvements consist of a new line around Nashville, with a modern hump yard located along it; a 95-mile new location from Brentwood, Tenn., to Athens, Ala.; a 20-mile new location from Blount Springs to New Castle, Ala., and numerous shorter changes of alignment and extensive changes of grade in the intervening stretches incidental to the double-tracking.

The work in Kentucky is partly a continuation of the grade reduction and double-tracking that has been going on for several years on the line from Cincinnati to Atlanta and partly new construction and reconstruction, as already stated, to provide a more economical outlet for the coal fields. The extent of this work is shown in the map and will be taken up in more detail later. The traffic on these lines is not balanced, the preponderance being the northbound coal. Grades were, therefore, established at 0.3 per cent north-bound and 0.5 per cent southbound. These gradese are being conformed to except on the new 27-mile line from Winchester to Irvine, where a 0.4 per cent north-bound grade was found to be the lightest feasible. The old grades were much heavier and were uncompensated for curvature, while east of Beattyville Junction on the Lexington & Eastern Railway there were curves of 10 and 12 deg. The curvature on the new work is limited to 6 deg. except for three 8-deg. curves near the far end of the improvement.

NASHVILLE CUT-OFF

The main-line improvement begins at Madison, about 9 miles north of Nashville. Three miles south of Madison, at Maplewood, a new line turns off and passes to the east of the city, crossing the Cumberland River on a new bridge 2800 ft. long and about 125 ft. above low water. The bridge will have a 300-ft., three 200-ft. and two 125-ft. spans, with steel viaduct approaches at each end. The new line will rejoin the present one at Overtons, about 6 miles south of Nashville. Between this junction and the river, Radnor yard is being constructed, a complete division yard in which about 52 miles of track are to be laid at once, space being provided for 13 additional miles. There will be receiving, hump-classification and advance yards in each direction, a complete engine terminal, and the other accessories of a modern yard.

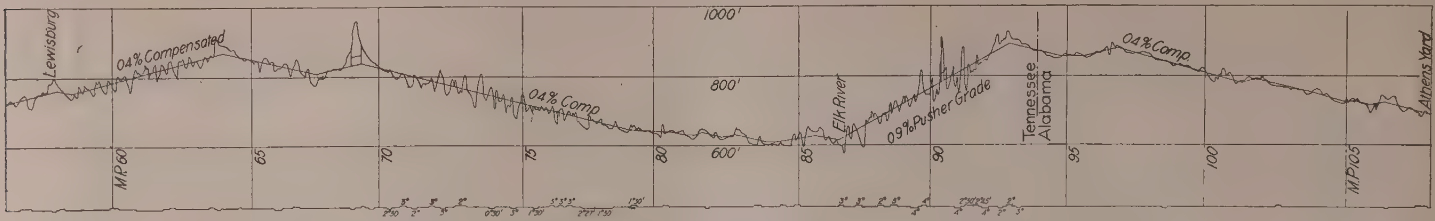
This line around Nashville will be double tracked except for the Cumberland River bridge, which will have only one track. North of the yards the ruling grade will be 0.5 per cent and south of them 0.4 per cent, conforming in each case to the present and proposed grades of the operating divisions of which they will be part. This new line will serve the triple purpose of removing through freight business from the congested lines through the city, taking out some of the sag in grade at the present Cumberland River crossing, and providing space for one adequate yard in place of the several cramped ones at present doing duty. On this line, as on all of the work being done by the company, highway grade crossings are being avoided wherever it can be done at a reasonable expense.

NEW BRENTWOOD-ATHENS LOCATION

For about 3 miles, from Overtons to a point south of Brentwood, the present line is being double tracked, with numerous alterations to alignment and grade. From Brentwood south, a distance of about 100 miles, to Athens, Ala., however, it was found that it would be cheaper to build an entirely new line than to bring the present line down to the established grade. The location of this new line is shown on one of the maps. It is about 5 miles shorter that the old line and has a maximum curvature of 4 deg., with tangents up to 6 miles in length. It has ruling grades of 0.4 per cent in each direction, with the exception of a 7-mile 0.9 per cent pusher grade south bound from the Elk River crossing. Curves on this as on all of the work being done by this company are compensated 0.035 per cent per degree.

The new location is a maximum distance of 28 miles from the old, and passes through a territory without railroad facilities, so that there are no towns of any great size on the route. On the other hand, the present line traverses a populous region, and it was considered neither feasible nor desirable to abandon it. For that reason the new line is being built as a single-track line, probably carrying most of the through freight in both directions. The present line will also be operated as a single-track line, probably carrying all the local freight and the passenger business and affording a relief for the new line in times of heavy traffic.

In building the new line, however, account is being taken of the probability that it will ultimately have to be double tracked. Culverts, therefore, in which the 13 ft. of additional barrel would not be expensive, as compared with removing and rebuilding end and



Condensed Profile and Alignment Diagram of New Location from Lewisburg to Athens Yard

wing walls at some later date, are being built for two tracks. Some of the deep rock cuts, also, in which it is believed that blasting and other excavating operations at some later date would interfere with and endanger the operation of the single-track line, are being made full width for two tracks. On the other hand bridge piers in water, stub abutments, and other concrete structures in which the addition of 13 ft. for a second track at some future time would not involve the removing or wasting of present construction, are being built for one track only.

ATHENS-BIRMINGHAM SECTION

From Athens south for several miles the present line is being double tracked and changed as to grade. For about 2 miles north of Decatur the Louisville & Nashville has no line of its own, but operates over the single-track line of the Southern Railway, which includes the single-track bridge over the Tennessee River. A short double-track cut-off will establish a new junction point about 1 mile south of the old one and reduce the single-track system to about 1 mile.

Heavy Rock Cut on the Revised Alignment up Sand Mountain, the Old Track Showing on the Left

Just south of Decatur more double-tracking begins, and extends, as shown on the map, to Blount Springs. Here also are changes of alignment of from a few hundred feet to 8 miles in length, and where the present alignment is retained the tracks are raised or lowered as much as 20 ft. From Wilhite to Holmes Gap, a distance of 5 miles, the old line follows a narrow ravine up Sand Mountain on about a 1.25 per cent grade, with many curves, uncompensated. About half of the curvature is being taken out and the rest compensated, but no attempt is being made at this time to construct a lighter grade than 1.25 per cent. This, it is figured, will balance well as a pusher grade with the 0.5 per cent ruling grade established from Decatur south, making it possible for two ordinary road engines to move up the grade any train that one of the engines could haul over the rest of the division.

Beginning at Blount Springs the old line is again left and rejoined at New Castle. This new portion, which is a maximum of about 5 miles from the old right-of-way, is about 22 miles long and saves about 2 miles in distance. As the old route does not pass through any important places it is proposed to abandon it, and the new line is therefore being built for two tracks.

From New Castle the present line is being double tracked and otherwise improved for the remaining 7 miles to Boyles, which is the main junction point on the outskirts of Birmingham.

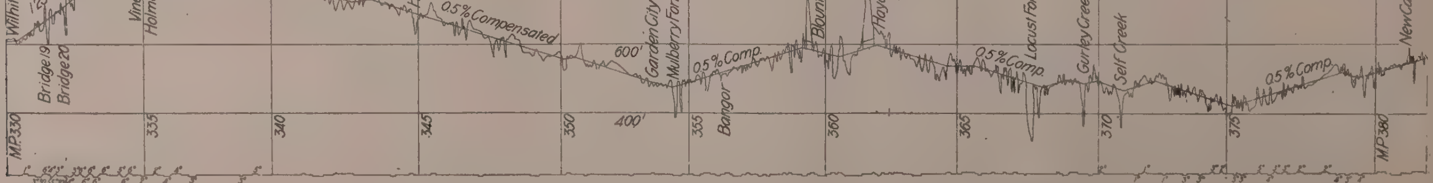
WORK IN KENTUCKY

Double-tracking and grade revision south from Cincinnati on the line to Atlanta have already been practically completed on a previous program as far south as Paris, Ky., and the first part of the new work in this section is the extension of the completed work for 16 miles, from Paris to Winchester.

The Lexington & Eastern Railway has recently been acquired by the Louisville & Nashville. This line, part of which is shown in the accompanying illustration, runs southeast from Lexington into the mountains near the Virginia boundary. It crosses the Cincinnati-Atlanta line of the Louisville & Nashville at Winchester, and passes through the eastern terminus, Beattyville Junction, of the Louisville & Atlanta division, which, as shown, crosses the Cincinnati-Atlanta line at Richmond. Since acquiring this line the company has extended it eastward to a point called McRoberts, thereby reaching an extensive new coal region. The Lexington & Eastern Railway was cheaply built, with heavy grades and curvature, and in order to adapt it to the handling of a heavy tonnage of coal it was at first intended to improve it on its present line. It was found on careful investigation, however, that rather than attempt to do this from Winchester to Beattyville Junction it would be more satisfactory to build the new line shown from Winchester to Irvine, utilize the Louisville & Atlantic division from Irvine to Maloney, and from there build the cut-off shown to Tallega.

The line from Winchester to Irvine will be about 27 miles long. Owing to the rough topography it was found impossible to get the northbound grade lower than 0.4 per cent. The line will have five high viaducts, the principal one being that over the Red River, which will be 1800 ft. long and about 190 ft. above low water. The road will be built for single track throughout, with a maximum curvature of 6 deg.

At Irvine a yard and an engine house will



Condensed Profile and Diagram of Alignment of Ultimate Line from Wilhite to New Castle be built, thus creating an operating division of satisfactory length, about 120 miles, from McRoberts and an opportunity to switch out the cars to and from the line through Richmond. The bulk of the freight is expected to go north, and another operating division will extend from Irvine to the DeCoursey yards near Cincinnati. This division will also be about 120 miles long.

From Irvine to Beattyville the present route, 34 miles long, following the windings of the Kentucky River, will be used. For the present the work along this section will be confined to the filling of bridges and improvements of grade and alignment at a few points.

The cut-off from Maloney, 2 miles east of Beattyville, to Tallega will be about 5 miles long, and will include bridges over the North and Middle Forks of the Kentucky River. From Tallega the old grade will be revised for 3 miles further to Athol. Here a maximum curvature of 8 deg. will replace existing curves of 12 deg. or sharper. The northbound ruling grade from Athol to Irvine will be 0.3 per cent; the southbound ruling grade will be 0.5 per cent.

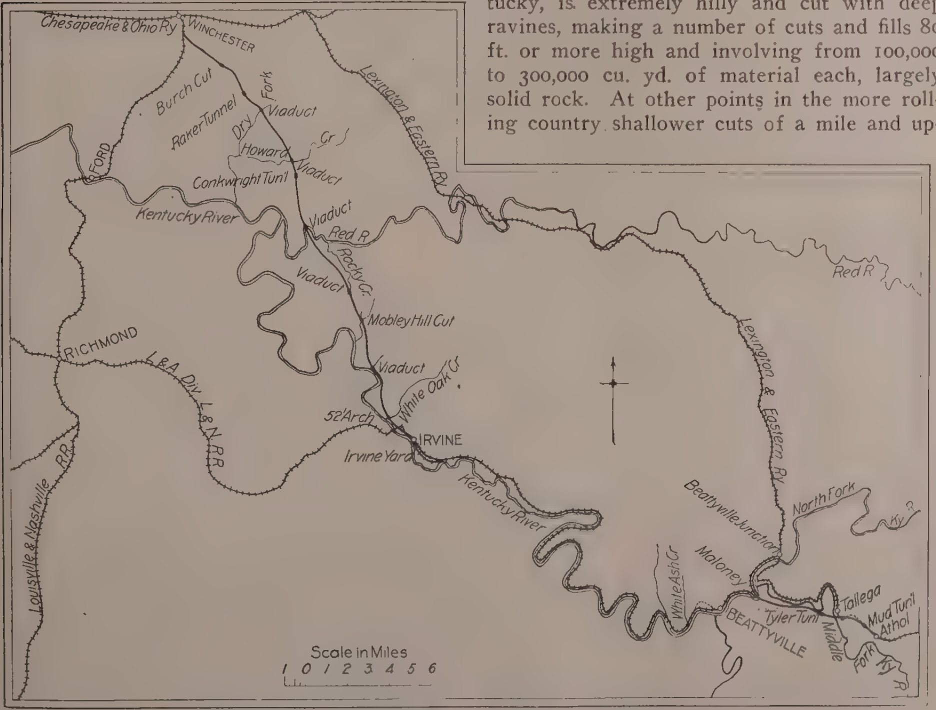
Beyond Athol there will be only minor changes, and the short section from Maloney to Beattyville Junction will also be raised somewhat to bring it above high water.

Combination Culvert and Undercrossing at White Ash Creek

MASONRY

Throughout all of the work above described it has been the policy to use solid embankments with concrete openings wherever possible. For instance, in the 77 miles under improvement between Decatur and Birmingham there were, before the improvement began, 78 open bridges; in the revised line when it is finished there will be only nine.

A variety of types of both plain and reinforced-concrete structures is being used, details of some of which will be shown in subsequent articles. For openings up to 10 or 12 ft. in width floating reinforced box culverts have been used to a large extent. Where pipes are used, those under embankments 20 ft. or less in height are in short lengths with locked joints, while those under higher embankments are in long lengths. Wherever sufficient headroom is available highways are being carried through semicircular arches. The arches over waterways are in general three-centered, with the shorter radius at the top. Some of the arches are being reinforced throughout, but in general mass arch rings are being used bearing directly on the solid-rock foundations, with thin reinforced and buttressed wing walls. As some of the embankments are 80 and 100 ft. high, a number of the culverts are more than 300 ft. long, and several of the arches are of 80-ft. span. Reinforced bridge abutments are being used to a large extent, some of which will be described in detail in later articles. In the masonry work three different classes of concrete are being used: Class A, of which the proportions are 1:2:4, is used for reinforced floating-box culverts and for thin reinforced sections; Class B, 1:2½:5, is used for the more massive reinforced parts; and Class C, 1:3:6, is used for foundations and mass concrete.



Map Showing Scope of Improvements in Eastern Kentucky

GRADING AND ROADBED

Most of the country traversed by the new lines, particularly that in Alabama and Kentucky, is extremely hilly and cut with deep ravines, making a number of cuts and fills 80 ft. or more high and involving from 100,000 to 300,000 cu. yd. of material each, largely solid rock. At other points in the more rolling country shallower cuts of a mile and upward in length are being made in order to get the grades down to the figures fixed. On the various parts of the work there will be eight tunnels ranging from 500 to 2100 ft. in length. Seventy-nine steam shovels are engaged in the work in the three states.

The roadbed sections for single track are 20 ft. wide on fills and 24 ft. in cuts. The centers for double track are 13 ft., the fills and cuts being respectively 33 ft. and 37 ft. in width. The long cuts, however, are being made wider at the lower ends, to provide better drainage. In general 90-lb. rail is being used on all of the work, and stone or slag ballast to a depth of 12 in. Sidings, as well as the tracks in the Radnor and Irvine yards are being laid out for 75-car trains with engine and caboose.

PERSONNEL

The work above described is being carried out under the direction of Mr. John Howe Peyton, chief engineer of construction, assisted by Mr. W. E. Smith, superintendent of construction, and Mr. H. C. Williams, assistant chief engineer of construction. Mr. W. H. Courtenay, chief engineer, has charge of the preparation of the plans. The section from Athens to the junction with the Southern Railway near Decatur is being done by company forces under the direction of Mr. Theodore Speiden, Jr., roadmaster, assisted by Mr. C. H. Crawford, resident engineer. The rest is being done by contract. Mr. W. S. Morton, division engineer, is in charge of the work from Madison to Lewisburg, with the exception of the Radnor yards. Mr. G. W. Feagin, division engineer, has the section from Lewisburg to Athens, Ala. Mr. T. Q. Harrison, engineer of construction, is in charge of the work from Decatur to Birmingham, with Mr. Leigh Talliaferro as his principal assistant. The work from Paris to Winchester, Ky., as well as that near completion north of Paris, is under the supervision of Mr. H. G. Laird, division engineer, while Mr. E. D. Sloan, assistant engineer, has charge of all the rest of the Kentucky work, except the Irvine yard. The Radnor and Irvine yards are both under the direction of Mr. E. L. Trowbridge, who is assistant engineer of construction.

METERING WATER AT ALBANY, N. Y., is again recommended in the annual report of the Bureau of Water for the year ended Sept. 30, 1912. The consumption in 1912 averaged 242 gal. per capita daily.

Micro-Organism Troubles and Mechanical Filters

Paper, Slightly Condensed, Presented before American Waterworks Association at Minneapolis by Frederick H. Stover, Bacteriologist and Chemist, Louisville Water Company

The chief functions of water filters being the removal of bacteria and suspended matter the natural inference would be that the operation of the plant would be easiest at the times when these substances are present in least amount. Many filter superintendents, however, find that such is not always the case and that warm weather and clear water bring troubles peculiarly their own. The usual symptoms of these troubles are marked shortening in the length of the filter runs and the prevalence about the filter beds of a pronounced odor, varying from "grassy" to "fishy" in nature. Microscopical examination of the water at such times usually reveals the presence of numerous minute forms of the type generally classified by waterworks men as "micro-organisms," which, in the waters of the Ohio River, are principally diatoms, with a few algae and miscellaneous forms present.

These organisms are usually accompanied by considerable amounts of very fine flocculent, amorphous matter, which, in part at least, is probably the result of bacterial action upon various organic substances. Since it is often present in increased amounts when these micro-organisms abound, it is extremely likely that part of it is also due to the activities of these forms.

The river water at such times usually has a turbidity of less than 30 parts per million and frequently as low as 5 to 10 parts per million, while the bacterial count will vary from 300 to 3000 at the lower turbidities. These periods of clear water are coincident with the periods of least rainfall, and the river falls to its lowest stages during these times. These conditions of clear, warm and shallow water, abundant sunlight and sluggish current afford these micro-organisms the most favorable conditions for development and their numbers increase rapidly at such times.

At Louisville the water is pumped from the river into two reservoirs having a total capacity of 100,000,000 gal., and which allow of about four days' natural sedimentation before the coagulant is added. As these are simply open basins the organisms, in some cases, increase while passing through them, but the greater depth of water, 20 ft., renders the conditions somewhat less favorable than would be encountered in the shallower parts of the river.

Of the varieties of micro-organisms found in the water about 75 per cent are diatoms, the remainder belonging to the algae and miscellaneous groups. The forms of diatoms most commonly present are asterionella, synedra and melosira. It is only with waters of low turbidity that these troubles occur and then in marked degree apparently only when the number of organisms present exceeds 200 to 300 per cubic centimeter.

At these times the turbidity which is present consists of extremely finely divided particles and it is the opinion of Mr. Stover that each of these factors, micro-organisms, amorphous matter and fine turbidity, does its share in the shortening of the filter runs.

Low turbidities, averaging about 30 parts per million, occurred during the latter 10 days of September, 1912, at which time the water contained very few organisms and very little amorphous matter. During the first 20 days of this month filter runs averaged 40 hours between washings, while for the latter third of the month, when using this water of less turbidity, they dropped to an average of 25 hours, a decrease of 38 per cent.

With these very low turbidities it becomes increasingly difficult to secure a floc of proper size and consistency, and as a result the suspended matter is able to penetrate more deeply into the sand layer than under normal conditions. In the absence of any considerable number of organisms of amorphous matter this shortening of the filter runs was attributed to the fine turbidity alone.

Early in May, 1913, a gradual shortening of the filter runs was observed and microscopical examination of the water showed only from 20 to 30 organisms per cubic centimeter. Amorphous matter, however, was present in large amount and continued so for several days, the length of the filter runs decreasing from 30 to 11 hours in a period of 9 days, although the number of organisms present during this time never exceeded 200 per cubic centimeter and remained during most of the period considerably below this figure. An instance of the combined effects of all three factors was observed between the dates of May 9 and 24.

General Effects Upon Filters

The first sign of approaching trouble is usually noticed after using for several days a water having a turbidity of about 30 parts per million or less when a progressive decrease in the length of the runs commences. Filters which have been making 30-hour runs without reaching over 4 or 5 ft. loss of head will drop to 25 or 20 hours inside of a couple of days and will reach a maximum loss of head of 8 ft. in this time. In other cases successive runs will show a decrease of 25 to 50 per cent., especially as the runs drop below 25 hours, when the decrease has sometimes been so rapid that at the end of a few days the best runs would average only 2 to 3 hours in length.

At such times the surface of the sand in the filters seems to become abnormally hard and compact in a short time, and when broken up the sand grains show a slight tendency to stick together. This condition cannot be wholly corrected even by thorough washing.

Microscopic examination of the sand when in this condition usually reveals the presence of numerous diatoms and other organisms, apparently cemented together in a matrix of amorphous matter and fine turbidity. These living organisms, it is believed, accelerate the formation and retention of this gelatinous film on the sand grains. In support of this may be mentioned the following: During the period from May 19 to June 14, 1911, the number of micro-organisms in practically all the samples examined was about 600 per cubic centimeter, the variations from this number, except in one instance, being so slight that it may be said to have remained practically constant. Yet during this period the length of the filter runs steadily decreased, until application of copper sulphate was made on May 26, following which there was a general increase in the length of the runs for a period of 6 days.

The only observable difference in the water coming to the filters during this period was that it contained dead instead of living organisms. The amount of turbidity and amorphous matter and the number of organisms were practically unchanged, the shortening of the runs having been apparently due to the cumulative effects of a constant number of organisms.

A similar increase in the length of the runs has also been observed when the organisms in the water died, apparently from natural causes. The rise between June 6 and 8 is attributed to this cause, for at this time the effect of the copper sulphate treatment of May 26 was at an end and the higher turbidity of June 10 and 11 had not yet arrived. During the times that the turbidity curve remains approximately constant the increases and decreases in the length of the filter runs follow quite closely the variations in the number of micro-organisms present.

The decreases in the length of the filter runs of course cause correspondingly large increases in the amounts of wash water used. During the year 1912 the average amount of wash water used at Louisville was 2.05 per cent—the lowest average for any one month being 1.44 per cent. During the periods of shortened filter runs, however, the amounts will vary from 6 to 10.7 per cent.

Methods of Treatment

The methods of treatment tested have been of three kinds—killing by chemicals; attempted removal by increased coagulation, and obtaining a different character of water, as in by-passing the sedimentation basins and drawing direct from the river.

The use of hypochlorite of lime for this purpose had been considered early in 1911, but before an opportunity offered for a trial of it some results of its use in this way were published by Mr. J. W. Ellms, of Cincinnati, in the spring of 1911. His experiments were attended by some success, but the results were not all that could be desired. One of his conclusions was that the nearer the hypo was applied to the filter beds the better the results in increasing the length of the filter runs, and that hypo applied directly to the filter beds gave the best results of all.

Not being equipped with devices for applying hypo accurately as a continuously fed solution, it was decided to apply it as a powder to one of the filter beds. This was done by draining off the filter until about 3 in. of water remained on it and scattering the powder uniformly over the surface, after which the bed was allowed to stand for a period of 24 hours. It was then washed and put into service.

No improvement in the length of the runs followed this treatment, and the bacterial efficiency of the bed for several days following was much below normal. The amount of hypo used was 12 lb. on a filter 30 x 72 ft. in size. No further experiments were made with the hypo.

Use of Copper Sulphate

With the copper sulphate applications markedly favorable results have been secured in all but one instance, and even in this case the results cannot be said to have been negative, as the runs were kept at 6 hours and above under conditions when much lower ones might have been expected, and probably would have occurred had not the copper been used. The minimum length of runs reached at this time was 5 hours, which occurred 9 days after this dosing.

Within 24 hours after the application of the copper there was in each instance a noticeable increase in the length of the filter runs and that these lengthened runs continued for periods varying from 8 to 19 days in length.

The copper was applied in the second sedimentation basin and in the coagulant basin by dragging bags of it from a boat. It is probable, however, that equally good results could be obtained by applying it as a solution, in a manner similar to that by which alum or hypo are applied.

In plants not provided with sedimentation basins, but which run the incoming water direct to coagulant basins, at least 12 hours should be allowed between the application of the copper and the filtering of the water and a slightly longer period would be desirable if possible.

The accompanying table shows the cost and amount of the chemical used in the various treatments were as follows:

AMOUNT AND COST OF COPPER SULPHATE TREATMENT

Date	CuSO$_4$ Used		Effects lasted (Days)	Total cost	Cost per mil. gal.		*Value wash water saved
	Pounds	P.p.m.			Dosed	Treated	
Aug. 20, 1910	650	1.3	19	$31.20	$0.50	$0.065	.....
May 27, 1911	735	1.3	10	36.00	0.52	0.104	$149.76
June 15, 1911	1000	1.7	9	49.00	0.70	0.217	228.50
June 10, 1912	625	1.2	9	30.60	0.49	0.132	.....

*At $30 per million gallons.

Some of these doses may seem rather large to those who have used this means for eliminating algae from a supply but it has been the experience of the writer that the diatoms offer rather more resistance to the action of copper than do the algae. It should also be borne in mind that from the reservoir to which this copper was applied about half the contents are drawn off daily. Theoretically there would be an entirely new supply of water in the reservoir every two days. Practically, on account of cross currents and other influences it takes much longer than this and the doses were effective over periods varying from 8 to 19 days.

Usually the length of the filter runs would begin to increase in from 12 to 24 hours after the application of the copper, and the beneficial effects lasted for the periods mentioned above. Hence in figuring the cost per million gallons filtered the cost was apportioned over the amount of water filtered during the period of increased runs following the application of the chemical.

A careful examination of the water from the basins, both as it flowed to the filters after coagulation and again after filtration, failed to reveal the presence of even a trace of copper. There were numerous fish in the reservoir, but except in the cases of a few very small and apparently newly hatched ones, practically none was killed. During and for a few hours subsequent to the application of the copper a few large fish were observed to come to the surface for a short time, acting slightly dazed, but it was apparently a temporary effect only.

The only drawback to the application of the copper is that a large increase of bacteria has been observed to follow its use, but this may be in some measure due to local conditions and need not necessarily be met with in other waters.

The explanation of this bacterial increase is probably that the killing of the micro-organisms and possibly some of the less resistant bacteria leaves some of the hardier forms in the midst of an abundant food supply and freed for the moment from any antagonistic effects of other forms. Hence a rapid increase follows for a short period. No B. coli were detected during this time, however, and it was found that the application of 0.25 part per million of available chlorine was sufficient to eliminate this increase, so that in plants provided with a sterilization plant this increase can be readily taken care of if it occurs.

The removal of the micro-organisms by increasing the dose of coagulant beyond that necessary for bacterial efficiency was tried but did not give results of a promising nature. Doubling the normal dose of coagulant increased the removal of the organisms by only 10 per cent and had very little effect on the runs.

The use of river water direct to coagulant basins was tried in two instances, and in both cases gave encouraging results, although in each case an increase in turbidity followed within a few days and thus left no opportunity to see how long this improvement would have lasted.

In addition to the regular determinations of micro-organisms and amorphous matter, the determination of the actual time of filtration of a given volume of the water under investigation has been found of value. This has been done by using what may be termed a miniature filter. In order to expedite matters the Sedgwick-Rafter filter, which is commonly employed to concentrate micro-organisms before counting, was used, and thus all the determinations were made by the use of one sample.

In the river sample of June 21, 1912, it was observed that the time of filtration of 500 cu. cm. through the Sedgwick-Rafter filter was only one hour as compared to about three hours for the water, which was coming from the sedimentation basins. The river sample contained about the same number of organisms, but much less amorphous matter than the sedimented sample.

The sedimentation basins were therefore by-passed and the river water run direct to the coagulant basins. An immediate increase in the length of the runs followed; the increase was from 5 to 9 hours in the following 3 days. A rise in turbidity occurring at this time put the runs back to normal.

The samples on which the time of filtration was noted were simply poured onto the small filter just as for an ordinary examination for micro-organisms, care being taken to use exactly the same amounts of sand and water in each instance. When the turbidity of the water exceeds 50 parts per million these small filters clog rapidly and this determination becomes of no value. This test has one advantage, however, in that it can be made by a person not familiar with micro-organism work and it does not require the use of a microscope.

SUMMARY

The water of the Ohio River, when of a turbidity below 30 parts per million, almost invariably causes decreases in the length of the filter runs. If such turbidities are accompanied by micro-organism and much amorphous matter, still greater decreases follow. Filter runs may be greatly increased by the judicious use of copper sulphate, although after-growths of bacteria sometimes follow its application and must be guarded against. Small doses of hypochlorite of lime do not affect these micro-organisms in such a way as to increase the length of the filter runs. The determination of the time of filtration of samples of water through small laboratory filters will in some instances enable the operator to select the water from that point of his system which will give the longest filter runs.

Tests of Road-Building Rocks

Since the road-material testing laboratory was established in the U. S. Department of Agriculture in 1900 several thousand tests have been made on samples of rock submitted from this and foreign countries. The records of the tests furnish an opportunity not only for comparing the wearing qualities of different kinds of rock but also for determining the relative values of three primary tests for this quality—the Page impact test for toughness, the Deval abrasion test and the Dorry hardness test. A comparison of this nature was made in a paper, of which this article is an abstract, presented before the American Society for Testing Materials at the Atlantic City meeting by Mr. Logan Waller Page, director of the Office of Public Roads.

HARDNESS VERSUS TOUGHNESS TEST

The relation between the qualities of hardness and toughness is best seen by reference to Fig. 1, on which are plotted the results obtained from the tests of 1538 samples of different kinds of rocks. The Dorry hardness coefficients are plotted as ordinates and the values for toughness as determined by impact tests as abscissæ. The results are plotted using all of the tests performed up to Jan. 1, 1911. The individual results for hardness are averaged for the different values of toughness and the averages are shown in large circles, which are the gravity centers of the small circles. The solid line very closely approaches the points marked by the large circles.

Reference to the plotted points will show a very definite relationship between the properties of hardness and toughness. It will be seen that as the toughness of a rock increases the hardness likewise increases, with the increase in hardness occurring at a rapid rate for low values of toughness and very slowly for the higher toughness values. When the toughness is low, a very considerable deviation of the individual from the average hardness results will be noted. On the other hand, when the toughness is high, the individual results for hardness more nearly approximate the average results. A very important fact to be noticed is that when the toughness is high, the hardness is invariably quite high. On the other hand, when the toughness is low, the hardness may be either high or low. It would seem, then, that although high hardness invariably accompanies high toughness, high toughness does not necessarily accompany high hardness. Another important point is the fact that when a rock has an average value for toughness, its hardness is likely to be of average value, or at least it will not be of unduly low magnitude. From a consideration of these facts it is apparent that a toughness test might be used for a quick determination of the road-building qualities of a rock to the exclusion of the hardness test, although the reverse is not true, since it is possible for a rock to have very high hardness and at the same time be of extremely low toughness.

The relation between average hardness and toughness may be expressed mathematically as follows:

$$(\text{Hardness} - 20)^2 \times (\text{Toughness} - 2.2) = 100$$

or

$$\text{Hardness} = 20 - 10 \div \sqrt{\text{Toughness} - 2.2}$$

This equation expresses quite accurately the relation between the average values for hardness and toughness, but for low values of toughness it has no usefulness because of the wide deviation of the individual from the average results. However, for high-toughness values the hardness of a rock may be calcu-

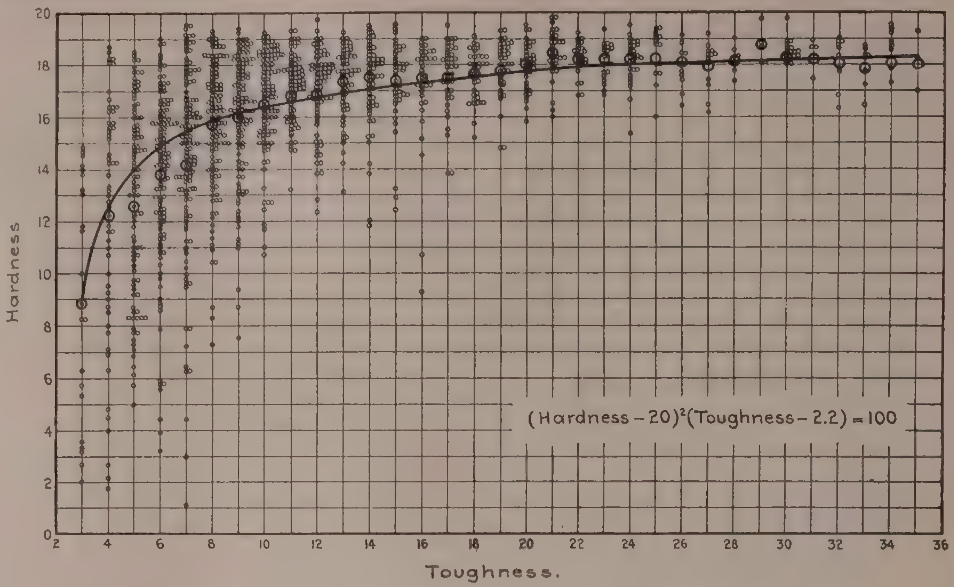


Fig. 1—Relation between Hardness and Toughness of Road-Building Rocks

lated with reasonable certainty, knowing the toughness. The assumption that a rock having infinite toughness will have the highest possible hardness coefficient, 20, was used in deriving the above equation. This seems to be a reasonable assumption in view of the tendency of the hardness to increase with increasing toughness. The equation was likewise made to satisfy the average ordinates on the curve.

Abrasion versus Impact Test

The relation between percentage of wear and toughness is plotted in Fig. 2 As in the previous curve, the ordinates are averaged, and the average values are plotted in large circles. In general, it will be noticed that the percentage of wear decreases as the toughness increases, at a rapid rate for low values of toughness and slowly for high values of toughness. The relation between the average values of hardness and toughness may be expressed as follows:

$$(\text{Percentage of Wear})^2 \times \text{Toughness} = 158.$$

The individual results for percentage of wear deviate considerably from the average results for low values of toughness. For high values, however, the deviation is not so serious. A rock with high toughness almost always has low values for percentage of wear, whereas a rock of low toughness may be either high or low in percentage of wear. The above relation, therefore, might be used to estimate approximately the percentage of wear of a rock when the value of the toughness is known, provided the toughness is high. It is impossible, however, to calculate the toughness when the percentage of wear is known. This equation was derived under the assumption that a rock of infinite toughness would have zero for a percentage of wear and a rock of zero toughness would have a high percentage of wear. At the same time the equation was made to satisfy the average of the plotted points.

Abrasion versus Hardness Test

In the relation between the percentage of wear and hardness it was not considered that a curve of averages would indicate anything of value in view of the wide distribution of the individual results over the plot. When the relations already given between hardness and toughness and the percentage of wear and toughness are combined there results a relation between percentage of wear (W) and hardness (H) expressed as follows:

$$W = \sqrt{\frac{6320\,H - 63200 - 158\,H^2}{88\,H - 980 - 2.2\,H^2}}$$

This equation expresses quite accurately the relation between the average values for percentage of wear and hardness, but it can be of no practical value in view of the wide deviation of the individual results from the average results. The relation between percentage of wear and hardness does not seem to be as definite as that between the percentage of wear and toughness and hardness and toughness.

The above relations seem to indicate that when the toughness of a rock is known the hardness test is one that might well be omitted, since high hardness in the rocks ordinarily used for road building accompanies high toughness. The wearing qualities of a rock might be determined very definitely either by means of the toughness test or with the Deval abrasion test. The toughness test, in view of the small sample required, is perhaps a cheaper test to perform than the abrasion test. The abrasion test has the somewhat doubtful advantage of requiring the use of larger and better averaged samples than the toughness test, although even this advantage may be offset by using a sufficient number of specimens in testing toughness. Judging from the foregoing considerations it is the writer's opinion that the prime quality to be determined in a road-building rock is that of toughness. The resistance to wear might also be obtained as very useful information, whereas the hardness test is of least value and might be omitted.

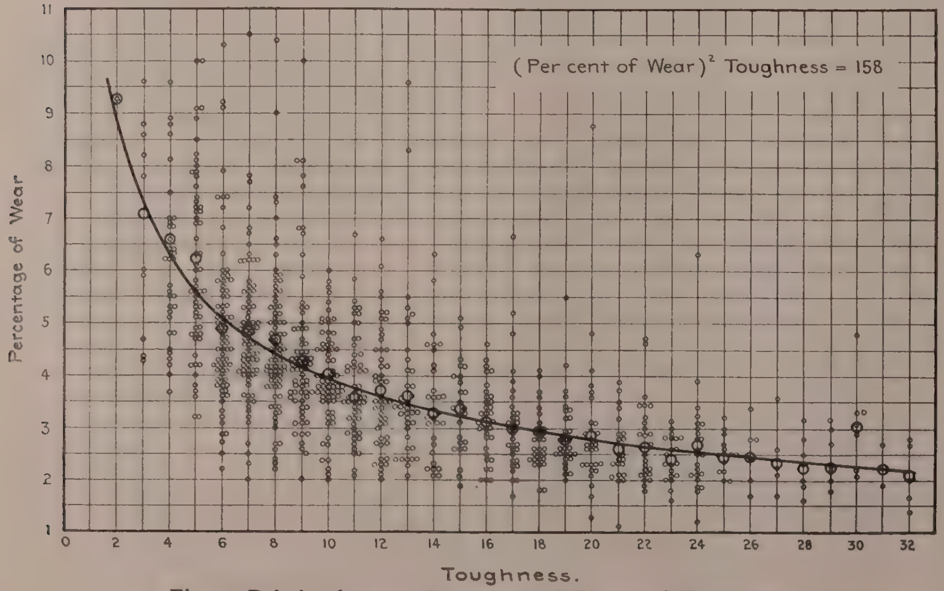


Fig. 2—Relation between Percentage of Wear and Toughness

Street-Car Operation on Heavy Grades in Severe Weather

As a means of relief from street-car congestion in one part of the city of Winnipeg it was proposed to divert some of the cars to a certain crossing over the Canadian Pacific Railway. This plan was opposed by the street-railway company on the ground that the excessive approach grades—found to be in each case 7.1 per cent for upward of 400 ft.—would make operation of cars over them dangerous. Investigation was made of problems similar as to grades and climatic conditions in other cities.

In Duluth, Minn., it was found that cars operate on a five-minute headway on an 8.73 per cent grade for more than 400 ft., the cars turning at the bottom of the grade into the principal street in the city. On another street they negotiate 800 ft. of continuous grades averaging steeper than 7.6 per cent. On these lines the only accident in five years was in the summer, during good rail conditions. The company has rigid rules as to operation on the grades, and has the rails salted and sanded by a special man during bad weather.

In Minneapolis cars operate over a 7 per cent grade, the same care being taken of the rails. In Milwaukee both city and heavy interurban cars operate over 300 ft. of an 8.7 per cent grade.

The foregoing is abstracted from the preliminary report of Mr. R. M. Feustel, appointed by the Manitoba Public Utilities Commission to inquire into the question of street-railway transportation and matters incidental thereto in Winnipeg.

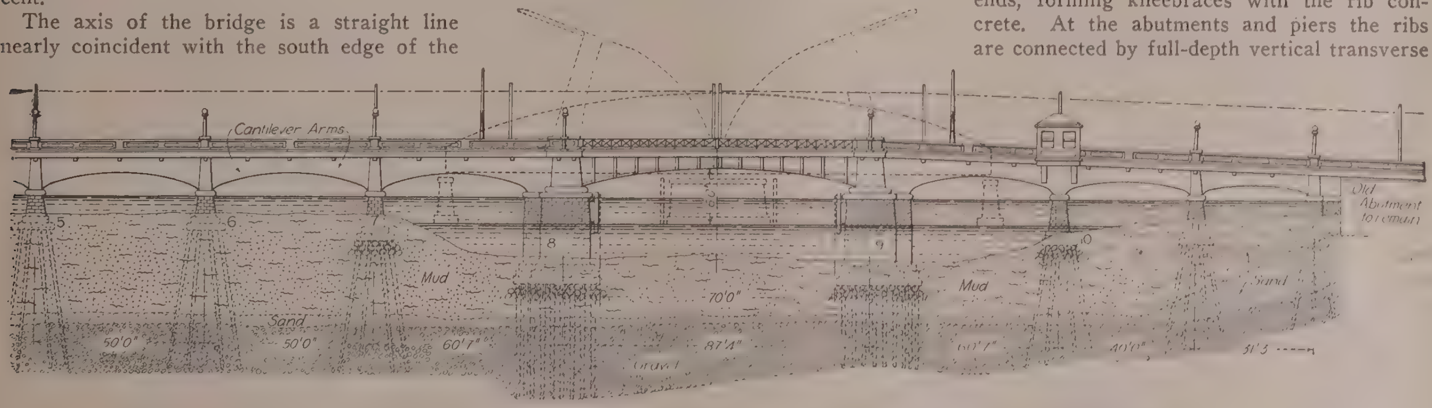
Testing of Large Scales by the Bureau of Standards of the U. S. Department of Commerce has been made possible by a Congressional appropriation for the purpose. This appropriation will be used to supply an equipment which will serve to provide means for testing scales, and will assure official standards heretofore lacking. A car will be furnished for housing and transporting the equipment proper, which will include eight 10,000-lb. weights, four 2500-lb. weights, and numerous smaller ones, making a total of more than 100,000 lb. Auxiliary equipment will include a motor truck for hauling the weights, a crane for handling them, a gasoline engine for supplying power, and sundry smaller appurtenances.

Washington Street Bridge in Norwalk, Connecticut

Ten Reinforced-Concrete Spans and One Double-Leaf, Bascule, Plate-Girder Span

The bridge now under construction in the line of Washington Street, South Norwalk, to carry highway and electric-car traffic across the Norwalk River has a total length, exclusive of paved approaches, of about 965 ft., an overall width of 60 ft., and a maximum clear height at center of roadway of 13.5 ft. above the mean high tide. It has two sidewalks and a 40-ft. paved roadway, with two electric-car tracks graded up from both ends to the center of the bascule span at a slope of 0.5 per cent, except for a short distance where there is a maximum slope of 3.5 per cent.

The axis of the bridge is a straight line nearly coincident with the south edge of the old pile-and-timber trestle bridge with a swing span and a width of about 35 ft. The old swing span, about 160 ft. long over all, had two clear openings of about 60 ft. each, which will be replaced by a single clear opening of 70 ft., on the same transverse center line. Part of the old approach trestle will be utilized in the approaches for the detour bridge and the remainder of the old structure will be removed, traffic during construction being maintained on an adjacent parallel by-pass temporary bridge with a 15-ft. roadway and a 4-ft. sidewalk.



Elevation of Typical Fixed Spans and Bascule Span, Showing Old Drawspan in Dotted Lines

The bridge is designed for a floor load of 40-ton electric cars on each track, or a 12-ton truck on any part of the roadway, and 100 lb. per square foot of surface not occupied by cars or truck. The girders are designed to carry the same car and track loads as the floor system, combined with 80 lb. per square foot on surface not occupied by cars. In addition the bridge is proportioned so that it will carry 50-ton cars with safety.

The bascule span is flanked on each side by one 60-ft. 7-in. fixed span, beyond which on the west there is one 40-ft. and one 31-ft. 3-in. fixed span. On the east there are six 50-ft. fixed spans; besides which there are at both ends concrete side-wall retaining approach fills, which at the east end are partly carried on pile and concrete supports.

The bascule piers are hollow and are supported on vertical piles. The fixed-span piers are solid and are supported on battered piles driven through mud to a considerable penetration in gravel. All piers are of concrete, faced, between high and low tide, with granite, and have footings carried below the bottom of the river and reinforced with longitudinal and transverse rods just above the tops of the piles, which penetrate the concrete 6 in. and are protected against scour by riprap.

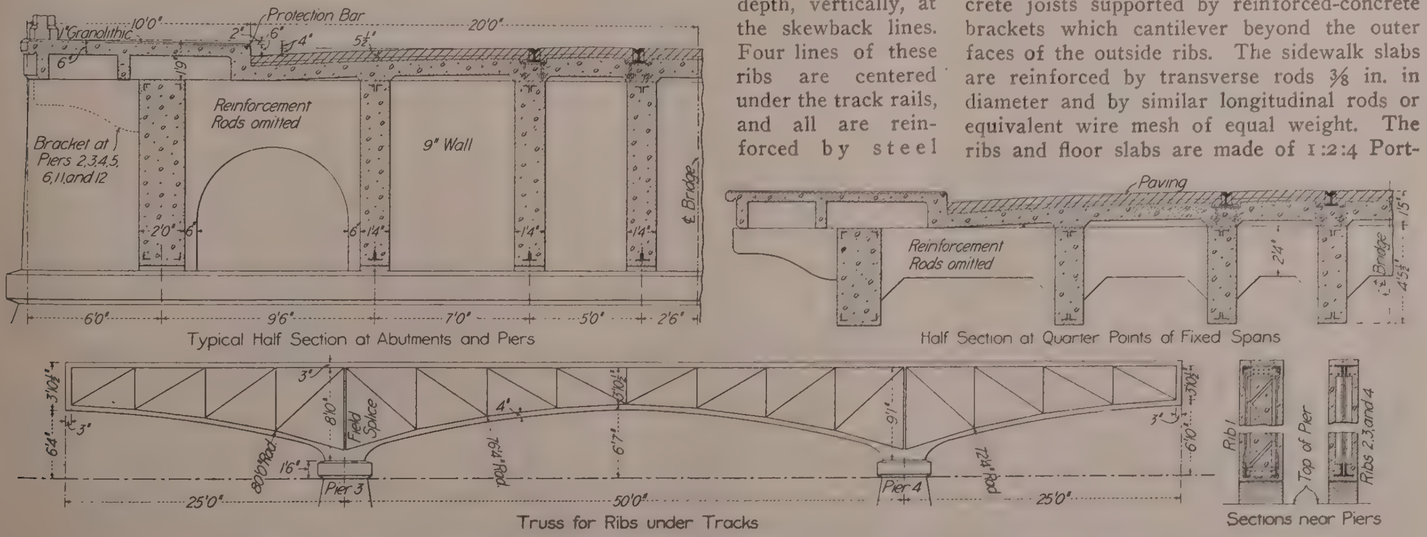
Fixed Spans

All of the fixed spans are of arched construction, the alternate ones consisting of two cantilever semi-spans anchored to the adjacent full spans and made continuous with them over the pier centers. This makes the construction continuous in sections of maximum length of 100 ft., and provides transverse expansion joints at moderate intervals. Each span has eight arch-like ribs or girders of rectangular cross-section, which in the 50-ft. spans are 4 ft. 5½ in. deep at the crown and of variable depth, vertically, at the skewback lines. Four lines of these ribs are centered under the track rails, and all are reinforced by steel trusses designed to be self-supporting during erection. The trusses are proportioned to carry all shear in excess of that provided for by the concrete, but they are not proportioned to carry all of the tension developed by the bending moment, part of which is provided for by horizontal tension rods embedded in the concrete adjacent to the top chords of the trusses. The outside ribs, although of the same depth as the intermediate ones, are made thicker than the latter, their reinforcement trusses having box-shaped top and bottom chords and a greater transverse width than the trusses of the intermediate ribs, which have T-shaped top and bottom chords.

The ribs are connected at half and quarter span points by 10 x 28-in. reinforced-concrete beams flush with the top flanges of the ribs. The beams have downward extensions at the ends, forming kneebraces with the rib concrete. At the abutments and piers the ribs are connected by full-depth vertical transverse concrete walls 9 in. thick, reinforced by vertical and horizontal rods in both surfaces. In one panel at each abutment the lower portion of the wall is removed to leave an arch-shaped opening of nearly the full width and about half the height of the panel.

The roadway is carried on a slab of reinforced concrete 8 in. or more thick, supported by the ribs, the curbs and the transverse beams. The transverse beams serve also as struts and as anchorages for the cantilever sidewalk brackets. The slab is continuous and is reinforced by longitudinal and transverse rods ½ in. in diameter. The upper surface has longitudinal recesses with anchor bolts cast in them to secure the rails which are set on 1-in. mortar beds.

The sidewalk slabs, which are 6 in. thick, are carried partly by the curbs, which are integral with them and with the roadway slabs, and partly on two longitudinal reinforced-concrete joists supported by reinforced-concrete brackets which cantilever beyond the outer faces of the outside ribs. The sidewalk slabs are reinforced by transverse rods ⅜ in. in diameter and by similar longitudinal rods or equivalent wire mesh of equal weight. The ribs and floor slabs are made of 1:2:4 Port-



Typical Half Section at Abutments and Piers

Half Section at Quarter Points of Fixed Spans

Truss for Ribs under Tracks

Sections near Piers

Transverse Sections, Showing Arch Ribs, Transverse Walls and Braces, and Details of Roadway land cement concrete with broken stone or washed gravel from ¼ in. to 1 in. in diameter. The solid reinforced-concrete parapets are paneled; their posts over the pier centers carry lamp fixtures.

Each bascule pier has two legs of 1:2½:5 concrete joined by two reinforced-concrete struts of 1:1½:3 concrete, and incloses a counter-weight pit. They are designed to resist maximum overturning loads of 20 tons on the extreme foundation piles. On the south side of the east bascule pier there is a concrete platform connected by concrete stairs to the sidewalk and by a wooden gangway bridge with a float or landing platform for small boats.

The bascule span will have a roadway pavement of wooden blocks and plank sidewalks. It can be operated in one minute by power furnished by the town's electric plant or in five minutes by hand power. The electrically operated safety gates controlled from the operator's house will be so interlocked with the bascule leaves as to prevent opening until the leaves are closed and locked. All machinery except the hand machinery for emergency operation of the bascule leaves will be controlled from the operator's house, which will be of concrete construction, supported on steel brackets incased in concrete and projecting beyond the north side of the bridge at pier 10, adjacent to bascule pier 9. All electric wires on the bridge are carried in fiber conduits incased in concrete.

The reinforced-concrete retaining walls for the east approach fills have L-shaped cross-sections, with inside buttresses 10 ft. apart and 9 in. thick, bracing the vertical portions to the trough-shaped footings that are seated on foundation piles. To prevent displacement of the soft mud under the weight of the fill on the east approach, the latter is carried on a reinforced-concrete slab supported on wooden piles. The fill above it is composed of sand and gravel, in which are built solid concrete footings for the posts carrying the trolley wires.

The total estimated cost of the bridge, including right-of-way and all construction and overhead charges, is about $400,000. Designs were made by and construction is under the supervision of Mr. J. E. Greiner, of Baltimore, consulting engineer for the Bridge Committee. Contracts were awarded on March 28 to McHarg, Barton & Company, of New York, for the construction of the reinforced-concrete bridge, to the Scherzer Rolling Lift Bridge Company, of Chicago, for the bascule bridge superstructure, and to Mr. Donald F. Toomey, of New York, for paving on the bridge and approaches.

Earnings from Water Power generated by the hydroelectric station forming part of the Wachusett dam of the Metropolitan Water Board of Massachusetts amounted to a net sum of $21,470 for the year 1912, according to Chief Engineer Dexter Brackett's annual report. The total quantity of energy generated was 5,741,588 kw-hours and 26,393,100,000 gal. of water under an average effective head of 90.8 ft. were used. The gross receipts from the sale of power were $30,465.66, and the cost of operating the station was $8,995.66, including an item of $2,675 for taxes. The net earnings per 1000 kw-hours generated were $3.74. Nearly all of the current was delivered to the Connecticut River Transmission Company under a 5-year contract which went into effect on Oct. 2, 1911. Mr. Brackett's report states that under all conditions the plant has given excellent service, with only an occasional minor trouble, which has been immediately remedied.

Statistics of Steam Railways in the United States

A preliminary abstract giving statistics of the steam railways of the United States for the fiscal year ended June 30, 1912, has been issued by the Interstate Commerce Commission. As these figures do not include returns for switching and terminal companies, nor for carriers having gross operating revenues for the year of less than $100,000, they may be somewhat modified by revision before they are presented in the full report.

Mileage.—The aggregate mileage of tracks of all kinds covered by operating returns for these roads was 360,714.24 miles. This was thus classified: Single track, 240,238.81 miles; second track, 24,929.51; third track, 2511.76; fourth, fifth, and sixth tracks, 1783.97; yard track and sidings, 91,250.19. These figures indicate an increase of 8925.52 miles over corresponding returns for 1911 in the aggregate length of all tracks, of which increase 3167.43 miles, or 35.49 per cent, represent yard track and sidings.

Equipment.—There were 61,250 locomotives in service on June 30, 1912, an increase of 979 over the previous year; 14,206 were passenger, 36,000 freight, 9475 switching, and 969 unclassified.

The total number of cars was 2,368,658, or 25,245 more than on June 30, 1911. This equipment was thus assigned: Passenger service, 50,606 cars; freight service, 2,203,128; company's service, 114,924.

Of the cars in freight service, there were classified 2,202,966, as follows:

Description	Number	Aggregate capacity, tons
Box	1,002,461	33,975,288
Flat	146,050	4,990,796
Stock	76,392	2,333,976
Coal	852,720	36,588,734
Tank	7,795	310,348
Refrigerator	30,681	950,530
Other cars in freight service	86,867	3,498,287
Total	2,202,966	82,647,959

The average number of locomotives per 1000 miles of line was 255, and the average number of cars per 1000 miles of line, 9860. The number of passenger-miles per passenger locomotive was 2,263,019, and the number of ton-miles per freight locomotive was 7,077,428.

Employees.—The total number of persons on the payrolls of these steam roads on June 30, 1912, was 1,699,218, or an average of 707 per 100 miles of line. As compared with corresponding returns for June 30, 1911, there was an increase of 45,987. There were 63,558 enginemen, 66,408 firemen, 49,051 conductors, 135,959 other trainmen, and 39,530 switch tenders, crossing tenders, and watchmen.

The complete report will include summaries showing the average daily compensation of eighteen classes of employees for a series of years, and also the aggregate amount of compensation reported for each of the several classes. The total amount of wages and salaries paid to railway employees during the year for the roads under consideration was $1,243,113,172.

Capitalization.—On June 30, 1912, the par value of the amount of railway capital outstanding was $19,533,750,802. This amount includes capital held by the railway companies concerned as well as by the public. Of the total capital there existed as stock $8,469,560,687, of which $6,882,813,008 was common and $1,586,747,679 was preferred; the remaining part, $11,064,190,115, representing funded debt, consisted of mortgage bonds, $8,019,700,886; collateral trust bonds, $1,279,128,266; plain bonds, debentures and notes, $1,067,567,350; income bonds $263,441,054; miscellaneous funded obligations, $116,170,300; and equipment trust obligations, $318,182,259.

Of the total capital stock outstanding $2,909,693,873, or 34.35 per cent, paid no dividends. The amount of dividends declared during the year (by both operating and non-operating companies) was $400,432,752, being equivalent to 7.20 per cent on dividend-paying stock. The average rate of dividends paid on all stocks outstanding pertaining to the roads under consideration was 4.73 per cent. No interest was paid on $808,464,701, or 7.52 per cent, of the total amount of funded debt outstanding (other than equipment trust obligations).

Investment.—The expenditures for additions and betterments, as well as the expenditures for new lines and extensions, during the fiscal year 1912 are analyzed in the tabulated statement at the bottom of this page.

Public Service.—The number of passengers carried during the year was 994,158,591, an increase over the previous year of 6,447,594. The number of passengers carried one mile was 33,034,995,806. The corresponding return for 1911 was 73,465,336 more. The number of passengers carried 1 mile per mile of road was 139,356, as against 142,859 for the preceding year.

The number of tons of freight reported as carried (including freight received from connections) was 1,818,232,193, while the corresponding figure for the previous year was 1,753,189,939, the increase being 65,042,254. The ton mileage was 262,955,605,123, an increase over the returns of 1911 of 9,499,215,886. The number of tons carried 1 mile per mile of road was 1,108,578, as against 1,088,314 for the preceding year. The average number of tons of freight per train-mile was 409.29, the corresponding figure for the preceding year being 386.17.

The average receipts per passenger per mile, as computed for the year ended June 30, 1912, were 1.985 cents; the average receipts per ton

Expenditures for Additions and Betterments and for New Lines and Extensions

	Expenditures for additions and betterments.	Expenditures for new lines and extensions.		
Investment to June 30, 1912			$15,895,657,969	
Investment to June 30, 1911			15,518,264,612	
Increase 1912 over 1911				$377,393,357
From cash or other working assets	$187,976,646	$59,872,304		
From special appropriations	32,553,291	183,613		
Through issue of securities	113,592,193	124,498,432		
Unassigned	2,134,855	3,554,933		
Total	336,256,985	188,109,282		
Total expenditures during year			524,366,267	
		Credits.		
Property retired or converted		$67,371,604		
Adjustments		17,290,466		
Difference between record value of grantor and purchase price of grantee in case of roads sold, merged, consolidated, etc.		62,310,840		
Total			146,972,910	
Net increase during year				$377,393,357

per mile, 0.743 cent. The passenger-service train revenue per train-mile was $1.30.404; the freight revenue per train-mile was $3.04.015. The average operating revenues per train-mile were $2.30.201. The average operating expenses per train-mile were $1.59.544. The ratio of operating expenses to operating revenues was 69.30 per cent.

Revenue and Expenses.—The operating revenues of the railways represented (average mileage operated 237,809.09 miles) were $2,826,917,967; their operating expenses were $1,958,963,431. The corresponding returns for 1911 (average mileage operated 234,366.14 miles) were: Operating revenues, $2,772,733,828; operating expenses, $1,901,399,475. The following figures present a statement of the operating revenues from 1912 in detail:

Freight revenue	$1,956,802,927
Passenger revenue	657,422,999
Excess baggage revenue	7,473,128
Parlor and chair car revenue	658,800
Mail revenue	50,674,758
Express revenue	72,970,758
Milk revenue (on passenger trains)	8,323,683
Other passenger revenue	5,228,969
Switching revenue	29,331,726
Special service-train revenue	2,078,910
Miscellaneous transportation revenue	6,174,062
Total revenue from operations other than transportation	27,367,678
Joint facilities—debit	—918,586
Joint facilities—credit	3,328,155
Total operating revenues	$2,826,917,967

Operating expenses, as assigned to the five general classes, were:

Maintenance of way and structures	$363,495,583
Maintenance of equipment	448,303,785
Traffic expenses	60,568,586
Transportation expenses	1,013,340,697
General expenses	73,254,780
Total operating expenses	$1,958,963,431

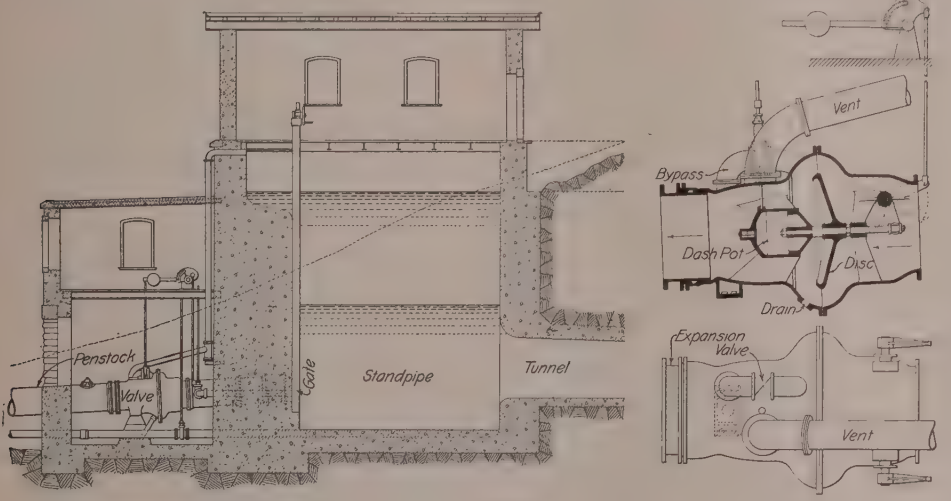
With minor eliminations from the figures given above, operating revenues per mile of line operated (including line operated under trackage right) averaged $11,881 and operating expenses $8234 for the year.

Public Participation in Forest Administration is aimed at in a new regulation promulgated by the Forest Service of the U. S. Department of Agriculture, in which provision is made for any association representing a majority of the local residents using the national forests to send a committee to act in an advisory capacity in settling questions which may arise in the districts in which they are immediately interested.

Brake Arrangement for Flap Valves

The design of flap valves for closing the mouths of penstocks under high heads has received considerable attention from Norwegian engineers. One of the most important requisites is that they shall be proportioned to withstand the impact of closing or be provided with some devise to prevent impact. In a recent issue of "Teknisk Ukeblad" some designs of flap valves, including those described below, were shown.

Various designs are shown in the accompanying illustrations. In all types illustrated the valves are unloaded by a by-pass and then hoisted by a chain to an angle of more than 90 deg. with the seat. Should it be necessary, in case of an accident in the power house or in the penstock line, to close the gate while the water is flowing at a high velocity it is evident that the flap must be retarded in some way to prevent its destruction. It is not desirable to connect the hoisting chain to a dashpot filled with oil or glycerin located above the water line, because the forces are so great as to break any chain or pin of reasonable dimensions. Dashpots have been installed in a large Swiss plant, but so far have not been tested.



General Arrangement and Details of Swiss Disc Valve

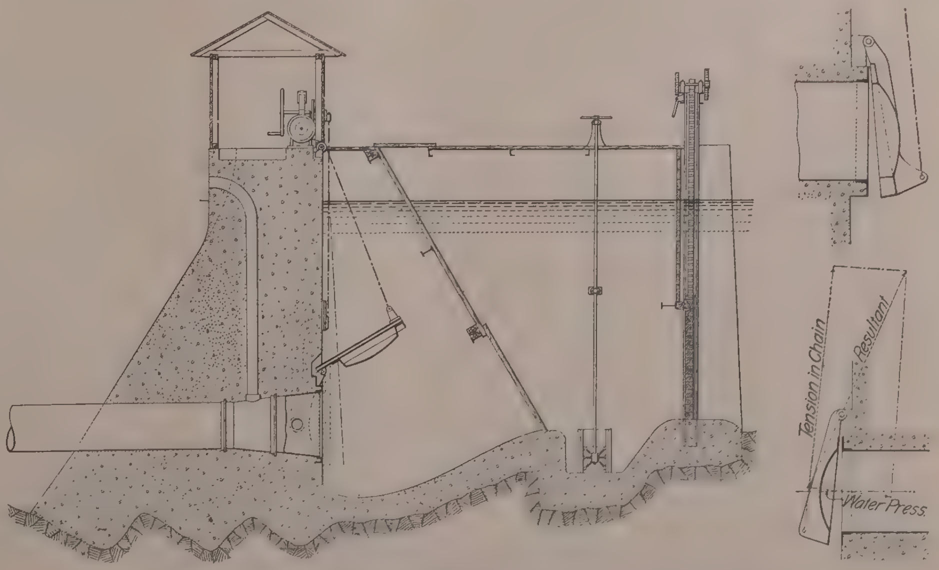
To obviate the disadvantages of the chain and dashpot arrangement, Messrs. Borchgrevink and Gregersens, two Norwegian engineers, have developed the brake arrangement which was briefly referred to in the Engineering Record of March 22, 1913, page 330, in connection with the description of the Samnanger power station. In this design the breaking force is automatically created around the rim of the gate by means of a tapering groove into which the gate seat projects. No attempt to brake the gate is made until it is nearly closed, when the water in the groove must be driven out between the valve and its seat through a continually decreasing space. It is evident, that as the space between the valve and seat becomes smaller, the braking force increases until the maximum is reached at the same time as the gate is closed.

The gate is held open by a chain wound around a drum. A brake on the drum can be electrically released from the powerhouse switchboard, thus permitting the valve to close.

In a number of Swiss plants there are automatic balanced gates which close the penstock as soon as the velocity of the water exceeds a given amount. The general arrangement is shown in one of the accompanying illustrations. The gate is located immediately below the forebay. The penstock is provided with an air vent downstream from the seat, so that when the gate closes the penstock is emptied of water without shock. To prevent the disc from closing too quickly a large dashpot is placed on the downstream side. The weight of the balancing lever is so adjusted that the gate can be made to operate at any desired velocity of the water in the conduit.

New Port of Bahia

The new port of Bahia in Brazil, which has been under construction for the past three years, will, when completed, according to a U. S. consular report, give the city thoroughly modern facilities and will accommodate steamers of all sizes. The new docking quays will have a frontage of 2750 ft. and a depth of water of 32 ft. A further frontage of 650 ft. with a minimum depth of 7 ft. will be provided for harbor launches and sailboats. There will ultimately be fifteen warehouses along the quay. Three of these are completed and in use; they are of structural steel finished with artificial stone, 300 x 65 ft., with 21,450 sq. ft. of floor space. Twenty movable steam cranes will convey the cargoes between the steamers and the warehouse doors.



General Arrangement and Details of Norwegian Flap Valves

Erecting 85-Foot Plate-Girder Spans with a Ginpole

The Hampden Railroad now being built from Springfield to Bondsville, Mass., to give the Massachusetts Central Division of the Boston & Maine Railroad a fast line from Springfield to Boston, involves a comparatively large amount of heavy construction, including about sixteen bridges and viaducts, among which there is a single track plate-girder bridge 61 ft. high and 410 ft. long over the Swift River and the Vermont Central Railroad. The bridge has three 85-ft. main deck spans and one 52 and one 72-ft. end spans, supported on two center steel towers, two concrete piers, and two concrete abutments.

On account of the heavy cuts which delayed tracklaying, the superstructure had to be erected before the grading had reached the site, so that the erection had to be carried on from the surface of the ground and at a height above it precluding the use of derrick cars. The use of travelers, falsework, or other expensive and complicated plant was eliminated by a method adopted of handling the girders by a ginpole.

Erecting a 10-Foot Steel Ginpole

Erecting a Plate Girder 75 Feet Long

The steel was delivered on the surface of the ground by the Central Vermont Railroad crossing under the second span from the west end of the bridge. It was unloaded from the cars and piled in storage by a guyed steel derrick with a 60-ft. boom, which also placed it on standard-gage cars on a service track running alongside the piers parallel to the bridge axis. The material was loaded on steel trucks and distributed to the positions required, and was unloaded from the service cars by a ginpole, which was used instead of a traveler.

Details of Ginpole

For the ginpole the 70-ft. mast of a steel guyed derrick of 40 tons capacity was rigged with eight 1-in. guy lines and a 12-part hoisting tackle, and was erected in the middle of the east-end span, seated on its regular foot block. The mast was revolved from horizontal to vertical position by a 4-part tackle attached to the top of the mast and to the top of the abutment, and the guys were anchored to timber deadmen buried in the ground in the usual manner. Each guy was provided at the upper end with a four-part manila adjusting tackle, with the lead line running vertically down from the block at the masthead, thence over a snatch block at the foot of the mast to the hoisting engine where it could be easily wound up on one of the spools.

After the moderate weight end span girders had been successively erected the foot block of the ginpole was shifted over to a position on the rails of the service track, and by careful operation of the guy lines and simultaneous pinching of the foot block the ginpole was moved in its erect position about 60 ft. parallel to the bridge axis to a location opposite the center of the second span and was then moved a few feet transversely to a position clear of the track on a timber crib built in the river to receive it. It was securely guyed and the 100-ft. girders, weighing 40 tons each, were successively delivered to it, hoisted to the required height, swung transversely to position in the required vertical planes by slacking off on the back-stay guys, and lowered to their seats on the tower by slacking off the hoisting tackle, after which the ginpole was moved in the same manner as before to position for erecting the second and third 100-ft. spans.

The position of the ginpole for erecting the third span was within reach of the guy derrick by which the steel had been unloaded from the railroad, and this derrick was used for taking down the ginpole. The hoisting tackle of the derrick was made fast to a sling engaging the ginpole above the center of gravity and after a strain was taken on it the guys were detached and the ginpole lifted, swung free and lowered to the ground.

Erection of Towers

The last span was completely riveted together in the shop and was erected as a unit by the guy derrick, which for this purpose was shifted about 75 ft. from the position it occupied when taking down the ginpole.

To avoid shifting either ginpole or derrick for the erection of the towers a cable was run from the top of the ginpole to the head of the derrick boom and beyond the ladder to an anchorage on the opposite side of the Vermont Central Railroad tracks. The derrick boom being securely guyed or anchored by its hoisting tackle, provided a rigid support for the cable, and the latter served substantially as a cableway, to which a hoisting tackle was attached at a point directly over the first bent of the tower. The tower bent was assembled and riveted together complete in a horizontal position on the surface of the ground and was revolved to position by the suspended tackle and guyed there while the tackle was released and erected the second bent and held it until both were braced together and developed permanent stability. The second tower was erected in a similar manner. The total weight of the bridge was 350 tons. The derrick and ginpole were operated by four two-drum, four-spool American Hoisting Derrick Company's hoisting engines.

The work was executed under the direction of Mr. Oren E. Parks, general manager of the Waronoco Construction Company. The superstructure of the bridge was fabricated and erected by Louis F. Shoemaker & Company.

Illinois Road Law

The Illinois road law, which received the signature of Governor Dunne a short time ago, provides for the construction of the main roads in the state by state aid, the unit for local control being the county, and the expense of the road construction being borne equally by county and state. The old law, which provided for a state-highway department with an unpaid highway commission, has been entirely rewritten. The new law establishes a state-highway department, consisting of three commissioners at a salary of $3500 each, a state engineer at $4000 per annum and an assistant state engineer at $2500 per year. All of the positions are to be filled by the governor, and except in the cases of the state and the assistant state engineer they are subject to ratification by the senate. All minor positions are subject to the state civil-service regulations.

The 1913 law does not require an engineering education for eligibility to the office of county superintendent of highways and favors for this position a resident of the county, but the duties imposed are such as come properly under the head of engineering, and the civil-service commission has the power to adjust its examinations so as to determine the fitness of a candidate for the position. The term of the office is six years and the salary is fixed by the county board.

The legal width of a public highway is made 40 ft. Bridges are considered a part of the state-aid roads. The sum of $700,000 a year is available for state aid and the maintenance of the department, $300,000 to be derived from the general revenue fund and $400,000 from the automobile-license fund.

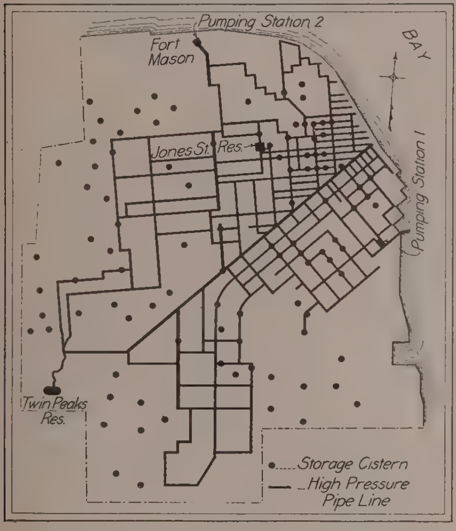
The Gatun Lake at Panama is now on its final rise to operating level, as it is not expected to open the spillway sluice gates again, according to the "Canal Record." At 10.40 a. m. June 27 the water surface was 48.25 ft. above sea level, and under normal conditions it is expected to reach 71 ft., the height of the railroad at Gorgona, about Oct. 1, and 85 ft. about Dec. 1. The top of the dike at Gamboa, protecting the Culebra cut from flooding through its north end, is 78.2 ft. above sea level, but it is expected that water will be let into the cut before the lake has reached that elevation about Nov. 1.

Auxiliary Water Supply for the Fire Protection of San Francisco

Combination of Cisterns and a High-Pressure Pumping System Drawing Water from the Bay or from Special Reservoirs

By A. J. Cleary, Assistant Engineer, Board of Public Works

The fire which immediately followed the earthquake of April 18, 1906, caused a property damage to San Francisco of approximately $325,000,000. Nothing daunted, the citizens removed the débris while some of it was still glowing and prepared for the work of reconstruction. This work has progressed steadily until a new city, architecturally more harmonious, structurally more permanent, has replaced the one that was destroyed. Elaborate precautions have been taken to safeguard the new city against a repetition of widespread catastrophe in case of future earthquakes. Much more attention has been paid to the structural details of buildings constructed since 1906. While it is true that a few poorly constructed buildings were completely demolished by the earthquake of that year, and a number of well-constructed buildings more or less severely racked, the damage was very slight when compared with that caused by the fire. Since the earthquake San Francisco has installed an auxiliary water system for fire protection which, it is predicted, will withstand any possible earthquake of the future.



Cistern and High Pressure Lines

Besides two fireboats for the protection of shipping interests and the waterfront, the system consists of two distinct parts. One is a storage system comprising a series of cisterns specially designed to withstand severe shock; the other is a high-pressure pipe-distribution supply, which includes more than 70 miles of various-sized pipe, together with reservoirs and pumping stations. The cisterns are intended for use only in case of serious damage to the high-pressure pipe system. Locations of cisterns and high pressure mains are shown in one of the drawings.

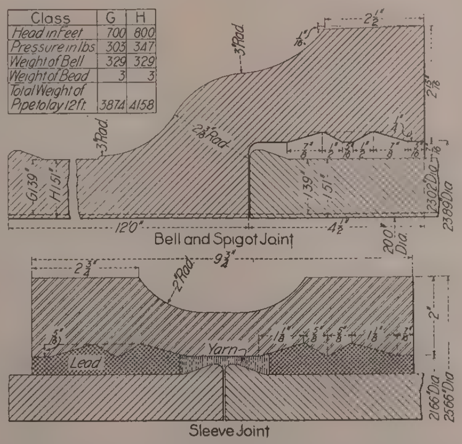
Storage Cisterns

Several brick masonry fire cisterns were constructed many years before the fire when San Francisco had no adequate domestic distribution system. As the Spring Valley Water Company improved and enlarged its network of distribution mains these cisterns fell into disuse, and at the time of the fire most of them were filled with débris instead of water. Even their location was unknown to the fire department. Since the fire they have been repaired and now form a small unit of the storage system. For the most part, however, new cisterns of reinforced concrete have been constructed—eighty-five in all. They are built beneath the surface at street crossings, and their exact position is indicated by a distinctive type of pavement over them. The inside diameter averages 30 ft. The top and bottom are diverging domes, as shown in the illustration. The maximum inside depth is 18 ft. 1 in., and the average capacity 75,000 gal. No fixed pipes for filling or emptying are rigidly connected with the cisterns, thus eliminating, should an earthquake occur, the disrupting stress exerted by a rigid connection upon the concrete structure, which should vibrate as a whole without injury.

Before locating a cistern on a particular corner a thorough investigation of existing structures, such as sewers, duct vaults, conduits and pipes, was necessary, since all of these data had been destroyed in the fire. This information was obtained by digging test trenches at the proposed corner and platting the structures. The cistern was then located in such a position as to disturb the least number of these structures.

When some of the first cisterns constructed were filled with water it was found that there were a number of serious leaks, despite the fact that the concrete used was a 1:2:4 mixture, waterproofed with 6 lb. of Medusa waterproofing compound to each barrel of cement. Investigation showed that this leakage was due to faulty tamping, since in every case it happened only where "honeycombed" areas existed in the concrete. The contractor was compelled to repair these leaks at his own expense, by removing the defective material and replacing it with a richer waterproof concrete. As this entailed considerable expenditure and loss of time in receiving payment, more care in tamping was exercised in subsequently constructed cisterns, and the latter showed absolutely no signs of leakage.

That the cisterns are capable of withstanding shock was conclusively proved when during the construction of one of them a rainstorm occurred and floated it 6 ft. above its foundation. As soon as the water had been drained away the closest inspection failed to detect any injury, and no leaks occurred when the cistern was filled with water.



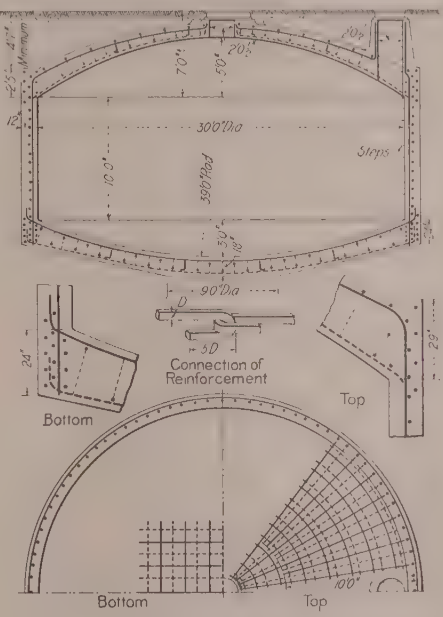
Class	G	H
Head in Feet	700	800
Pressure in lbs.	303	347
Weight of Bell	329	329
Weight of Bead	3	3
Total Weight of Pipe to lay 12 ft.	3874	4158

Joints Used on High Pressure Lines

The bell and spigot joint is used in solid ground; the sleeve joint in filled-in areas. Both types are used only where the pressures are more than 175 lbs. per square inch.

High-Pressure System

Seven square miles of San Francisco are now protected by the high-pressure system. The protected area is divided into two zones, the upper including those districts whose elevation is greater than 150 ft. This zone is supplied from a 500,000-gal. steel distributing reservoir at an elevation of 490 ft., situated on Clayton Street near Seventeenth Street. The lower zone comprises those portions of the protected area less than 150 ft. in elevation. It will soon be supplied by its own 1,000,000-gal. distributing reservoir at an elevation of 330 ft., now in course of construction at Jones and Clay Streets. Meanwhile both zones are supplied from the Clayton Street tank. When necessary to operate the system with a higher pressure than 150 lb. per square inch, provided by the distributing reservoirs, both zones can be connected directly with the main storage reservoir at an elevation of 760 ft., located near the summit of Twin Peaks. This reservoir consists of two compartments, with a capacity of 5,000,000 gal. each, and is constructed of reinforced concrete, as briefly described in the Engineering Record of June 29, 1912, page 713.

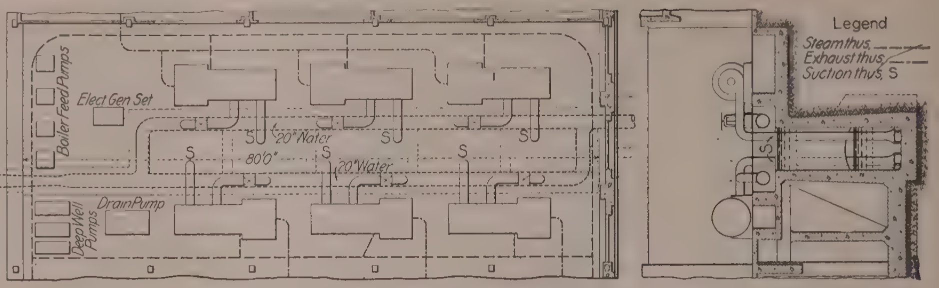


Typical Reinforced-Concrete Cistern

Pumping Stations

There are two salt-water pumping stations, one located at Second and Townsend Streets, the other on the United States military reservation at Fort Mason. Pumps were furnished by Byron Jackson Iron Works, of San Francisco, while Chas. C. Moore & Company supplied the boilers and mechanical equipment for the two stations. The Townsend Street station was built by the Healy-Tibbitts Construction Company and the Fort Mason station is being erected by Caldwell & Company. Both buildings are of reinforced concrete, and in their construction practically no combustible material was used. The roof trusses and covering of the Townsend Street station are exceedingly heavy, and the chimneys very heavily reinforced, that they may be as nearly as possible earthquake-proof.

The water supply for the pumps of each station is drawn from the bay through a tunnel lined with heavily reinforced concrete.

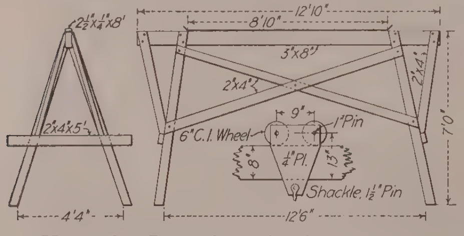


Layout of Pump Room, Townsend Street Station

The tunnels are below low-tide level, so that the water, after passing through the screens at the intake, flows directly from the bay into the station. In each station two separate pipes discharge from the pumps through an 18 x 10 in. Venturi meter into the distribution mains. Either 18-in. pipe is capable of carrying the entire capacity of the station.

The Townsend Street station is equipped with four Curtis turbine-driven pumps, each capable of supplying 3000 gal. per minute at a pressure of 305 lb. per square inch. They are of the four-stage type, 12 in. in diameter, 750-hp, and operate at 1800 r.p.m. They are non-condensing, since the initial cost of such a pump is less, and as they will not be operated continuously the difference in maintenance cost will be nominal. Steam is supplied by eight 350-hp. Babcock & Wilcox boilers. One 10-kw. electric-light engine, two feed pumps, two feed-water heaters, two oil pumps and two deep-well pumps complete the equipment. The deep-well pumps will be used to supply the boilers from six fresh water reservoirs under the building in case by any cause the supply from the Spring Valley Water Company's city mains be temporarily cut off.

The U. S. Government allowed the city to construct Station 2 on its Fort Mason military reservation, which occupies a portion of the north shore of the city near the end of Van Ness Avenue. The condition exacted by the military authorities was that the city should supply all the electric current required on the reservation for lighting and other purposes. Hence the four pumps installed at this station were designed as convertible-condensing or non-condensing. Six 400-hp. Stirling boilers will supply steam for these pumps, and also for one 50-kw. to two 100-kw. reciprocating engines, two feed pumps, one air pump, one circulating-water pump and engine, one condenser and two feed-water heaters. The reciprocating engines are of the condensing type.



Horse for Lowering Pipe into Trench

Cast Iron Pipe

The same precaution which was taken in designing the cisterns to provide for resistance to vibration was exercised in designing the high-pressure distribution system. Cast-iron pipe at the time the system was designed was thought best adapted to local conditions and was used throughout. In the chert formation that predominates in the hilly portions of the city and in the solid sand-clay formation of some of the lower districts the oscillation in the earthquake of 1906 was not nearly as pronounced as in the filled-in area, which constitutes a considerable part of the lower districts. A different type of pipe joint was, therefore, used in these two classes of ground. For the solid ground a bell and spigot-leaded joint was chosen, while in the filled-in area a double-spigot sleeve joint with steel sleeves was used. Both types are shown in one of the drawings. The double-spigot joint is capable of withstanding without excessive leakage or injury twice the amount of lateral distortion that the bell and spigot joint can undergo. Before a standard joint was decided upon an elaborate series of tests was conducted by the engineering department in order to determine a type of bell and spigot and spigot sleeve best adapted to withstand sudden lateral motion without injury to the strength of the joint or its resistance to leakage. The joints illustrated are used only for pressures over 175 lb. per square inch. They were the types which allowed the greatest distortion with the least leakage. For smaller pressure the bell dimensions and the thickness of the pipe for different heads conformed to the standard of the New England Waterworks Association.

The pipe was supplied under contract by the United States Cast-Iron Pipe Company, the lowest bidder. In all 95 miles of various sizes have been received. The price was $19.90 per ton for bell and spigot pipe and $20.50 per ton for double-spigot pipe grooved at ends, f. o. b. cars at Bessemer and Anniston, Ala. The freight was paid by San Francisco and amounted to $11 per ton.

Every piece of pipe, as well as all hydrants, gate valves and specials, was tested to a pressure of 600 lb. per square inch at the city's testing plant immediately upon delivery. They were then stored in the municipal pipe yard and supplied as needed to the various contractors. A locomotive crane was used in unloading the cars and loading the trucks. Each of the seven contracts for pipe laying was in charge of an assistant civil engineer, assisted by as many inspectors as were necessary to insure the fulfilment of the specifications. The city furnished to the contractor at the municipal pipe yard all the pipe, special castings, gate valves, hydrants, valves and manhole frames, covers and dustpans, pipe casing for valve boxes, bolts with nuts and washers, lead and lead wool for the joints, and wooden ducts for underground conduits.

For the separate telephone and telegraph system to be used in conjunction with the high-pressure system the ducts were laid in the same trench as the pipe except where existing unoccupied ducts were available.

For lowering large-sized pipe into the trench a steam hoist was used for a short time on the first contract awarded, but soon abandoned because it proved too cumbersome in the hilly districts and occupied too much space on crowded streets. The ordinary pipe tripod proved inefficient, so a framed pipe horse of the dimensions shown in one of the drawings was finally adopted.

When pipe was laid on steep grades and it was necessary to have any of the bells pointing down grade, instead of pouring the joint, lead wool was used. When properly calked such joints stood the tests as well as the poured joints. After several blocks of pipe had been laid and calked, in order to hold the line rigid under test the trench between joints was refilled. The joints were left exposed so that they could be examined for leakage.

Tests on Distribution System

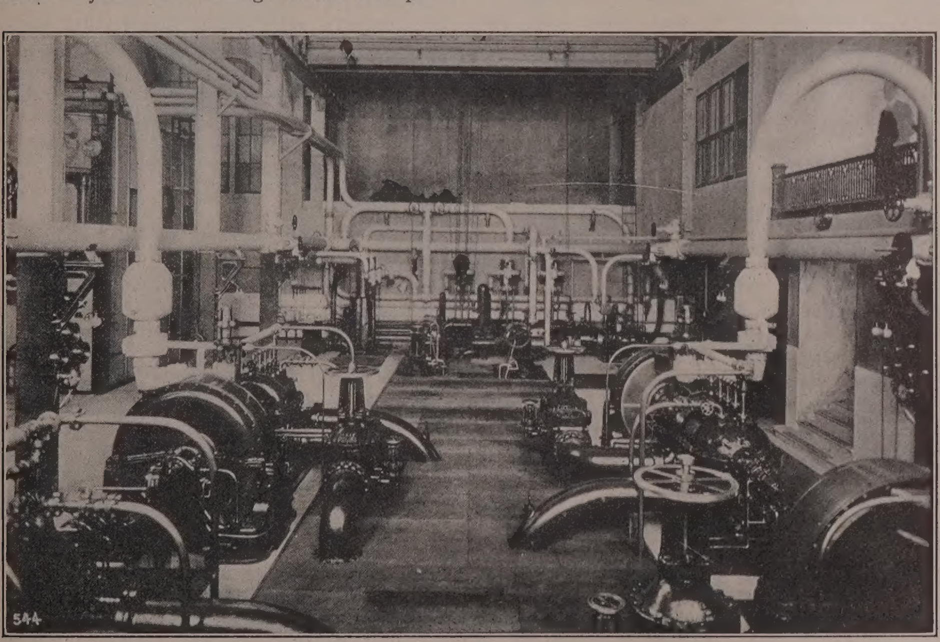
Under test the various classes of pipe were subjected to the following pressure:

Class of Pipe	Used for Head of	Test Pressure, lbs. per sq. in.
G & H	600 to 760 ft.	450
F	500 to 600 ft.	400
E	400 to 500 ft.	350
D	300 to 400 ft.	300
C	200 to 300 ft.	250
B	100 to 200 ft.	200
A	0 to 100 ft.	150

Townsend Street Station of the San Francisco High Pressure System

The pipe to be tested was first filled with water and the specified pressure obtained by means of a double-cylinder force pump. The exact time was then noted. The pressure was maintained for twenty minutes and the amount of water forced into the pipe during that period measured. This would represent the leakage in the pipe during the test, and if it amounted to more than 0.0055 gal. per lineal foot of pipe joint, which is equivalent to a leakage of 0.4 gal. per lineal foot of pipe joint in twenty-four hours, the contractor recalked whatever joints showed leakage until the line satisfactorily withstood the test.

The first tests conducted were made between adjacent valves. For mains 14 in. in diameter and over, when one of these valves was at the end of the line under test, it was almost impossible to secure a backing which was sufficiently rigid to prevent the valve moving longitudinally. The bell would slip outward along the adjoining spigot sometimes as much as 1 in. If the valve was bolted to the line, the motion would occur at the first unbolted joint. No leakage would take place until the valve was forced back by a similar test on the other side. Leakage then developed in the joint which had first slipped. To prevent this motion a plug with a rubber-cup gasket and a tap to admit water were used. This plug fitted loosely into the end of the pipe and a suitable backing was provided. With an increase of pressure the cup gasket expanded against the inside of the pipe and prevented leakage. Under test the plug could move outward as much as several inches, but hold the pressure without leakage and effectively prevent any movement in the line itself. Another advantage in the use of this plug was that it could be readily inserted in an open end of the pipe at any time, and after the test be removed immediately and pipe laying continued. The trench could, therefore, be backfilled and the street repaved much sooner than if tests could be made only between valves.



Pump Room in the Townsend Street Station

Pipe lines were run out on the docks at intervals along the waterfront, and pressure can be maintained in a portion of the system by the fireboats.

Since the installation of the auxiliary water supply for fire protection a material reduction in insurance rates has been made. This reduction will be increased when the Fort Mason pumping station and the last link in the pipe system, consisting of a 20-in. line from this station to the corner of Bay Street and Van Ness Avenue, are completed.

Costs of Cisterns

The cisterns described in this article were constructed by contract, but very accurate cost data were kept by the city's bureau of engineering. Following is a typical cost account for constructing the cistern shown in the drawing. This cistern was located at the corner of Fifth and Harrison Streets.

Detail Costs of Concrete Cistern

GENERAL EXPENSE.	
Labor Cost:	
Superintendent, 219½ hours at 87½ cents	$192.06
Timekeeper, 142½ hours at 31¼ cents; 5 hours at 50 cents	47.03
Watchman, 652 hours at 31¼ cents	203.75
Total	$442.84
Material Cost:	
Telephone	$28.50
Office rent and horse	21.00
10 gal. coal oil at 20 cents	2.00
Total	$51.50
REMOVING PAVEMENT.	
Labor Cost:	
Foreman, 15 hours at 43¾ cents	$6.56
Laborers, 220 hours at 25 cents	55.00
Team, 8 hours at 75 cents	6.00
Total	$67.56
EXCAVATION.	
Labor Cost:	
Foreman, 169½ hours at 43¾ cents	$74.15
Foreman, 46½ hours at 50 cents	23.25
Laborers, 1981 hours at 25 cents	495.25
Team, 317½ hours at 75 cents	238.12
Total	$830.77
Material Cost:	
Motor rent	$10.00
Electric power	10.00
Depreciation on equipment	50.00
Total	$70.00
LAGGING.	
Labor Cost:	
Foreman, 148 hours at 50 cents	$74.00
Foreman, 55 hours at 43¾ cents	24.06
Laborers, 754½ hours at 25 cents	$188.62
Laborers, 893¾ hours at 31¼ cents	279.29
Electrician, 77½ hours at 37½ cents	29.06
Total	$595.03
Material Cost:	
4410 ft., 2 x 8 R. P., at 15 cents	$66.15
1 keg nails	3.00
Total	$69.15
PUMPING.	
Labor Cost:	
Foreman, 11 hours at 50 cents	$5.50
Foreman, 29 hours at 43¾ cents	12.69
Electrician, 88½ hours at 37½ cents	33.19
Laborers, 240 hours at 31¼ cents	75.00
Laborers, 83½ hours at 25 cents	20.87
Total	$147.25
Material Cost:	
7½-hp motor, 4-in. pump, 105-ft. R. P., at $15 per M	$1.60
100-ft. T. & G., at $20 per M	2.00
Motor rent	30.00
Electric power	49.00
Installation fee	10.00
Total	$92.60
BOTTOM REINFORCING STEEL.	
Labor Cost:	
Housesmiths, 160 hours at 62½ cents	$100.00
Material Cost:	
2038 lb. ⅝-in. steel at $0.021	$42.80
4566 lb. 1-in steel at $0.021	95.89
Ties and spreaders	8.00
Total	$146.69
SIDE REINFORCING STEEL.	
Labor Cost:	
Housesmiths, 72 hours at 62½ cents	$45.00
Material Cost:	
1584 lb. ⅝-in steel at $0 021	$33.26
2529 lb. ¾-in. steel at $0.021	53.11
Total	$86.37
DOME REINFORCING STEEL.	
Labor Cost:	
Housesmiths, 84 hours at 62½ cents	$52.50
Laborer, 8 hours at 31¼ cents	2.50
Total	$55.00
Material Cost:	
1623 lb. ¾-in. steel at $0.021	$34.09
1829 lb. ⅝-in. steel at $0.021	38.40
3553 lb. 1-in. steel at $0.021	74.61
Ties and spreaders	8.00
Total	$155.10
BOTTOM CONCRETE.	
Labor Cost:	
Concrete foreman, 8 hours at 75 cents	$6 00
Concrete laborers, 102 hours at 50 cents	51.00
Foreman, 8 hours at 50 cents	4.00
Laborers, 160 hours at 31¼ cents	50.00
Teams, 8 hours at 75 cents	6.00
Total	$117.00
Material Cost:	
43 yd. rock at $1.40	$60.20
54 yd. sand at $1.50	8.10
60¾ bbl. cement at $2.45	148.84
360 lb. Medusa at 14½ cents	52.20
Depreciation on equipment	5.00
Total	$274.34
SIDE CONCRETE.	
Labor Cost:	
Foreman, 18 hours at 50 cents	$9.00
Carpenters, 3 hours at 50 cents	1.50
Laborers, 184 hours at 31¼ cents	57.50
Teams, 8 hours at 75 cents	6.00
Total	$74.00
Material Cost:	
216 sacks cement at 50 cents	$108.00
300 ft. Medusa at 14½ cents	43.50
33 yd. rock at $1.40	46.20
4½ yd. ocean sand at $1.50	6.38
5 yd. city sand at 50 cents	2.25
Total	$206.33
DOME CONCRETE.	
Labor Cost:	
Foreman, 7 hours at 50 cents	$3.50
Laborer, 92 hours at 31¼ cents	28.75
Concrete foreman, 8 hours at 75 cents	6.00
Concrete laborers, 94 hours at 50 cents	47.00
Engineer, 9 hours at 37½ cents	3.37
Team, 14 hours at 75 cents	10.50
Total	$99.12
Material Cost:	
2 M. H. covers and intake pipe	$25.00
270 sacks cement at 60 cents	162.00
6 yd. ocean sand at $1.50	9.00
20 yd. city sand at 50 cents	10.00
50 yd. rock sand at $1.40	70.00
Total	$276.00

SUMMARY OF CONCRETE CISTERN COST

	Labor	Material	Labor and Material	Quantities	Unit Cost
General expense	$442.84	$51.50	$494.34	....	....
Removing pavement, basalt blocks on 6-in. base	67.56	....	67.56	800 sq. ft.	$0.084 per sq. ft.
Excavation (sand)	830.77	70.00	900.77	690 C.Y.	$1.305 per C.Y.
Lagging (2 x 8 in.)	595.03	69.15	664.18	4,410 B.M.	$150.61 per M.
Pumping	147.25	92.60	239.85	....	....
Reinforcing steel	200.00	388.16	588.16	9.79 tons	$60.08 per ton
Concrete	317.24	779.62	1096.86	146 C.Y.	$7.513 per C.Y.
Forms	187.33	59.55	246.88	....	....
Backfill (sand)	47.06	....	47.06	....	....
Pavement and curb	102.93	75.50	178.43	....	....
Catch basin	16.87	14.40	31.27	....	....
Sidewalk	5.00	51.10	56.10	....	....
Total	$2959.88	$1651.58	$4611.46		

Inside Finish.	
Labor Cost:	
Foreman, 2 hours at 50 cents	$1.00
Laborers, 34 hours at 31¼ cents	10.62
Concrete foreman, 8 hours at 75 cents	6.00
Concrete laborers, 16 hours at 50 cents	8.00
Teams, 2 hours at 75 cents	1.50
Total	$27.12
Material Cost:	
27 sacks cement at 50 cents	$13.50
12 sacks cement at 60 cents	7.20
1½ sacks gravel at $1.50	2.25
Total	$22.95
Side Forms.	
Labor Cost:	
Carpenters, 39 hours at 50 cents	$19.50
Laborers, 62 hours at 31¼ cents	19.37
Total	$38.87
Material Cost:	
Depreciation on forms and bracing (Cost $107.70.)	$25.00
Dome Forms.	
Labor Cost:	
Carpenters, 66 hours at 50 cents	$33.00
Laborers, 51 hours at 31¼ cents	15.93
Total	$48.93
Material Cost:	
Depreciation on forms (cost $79.05)	$26.55
Depreciation on 1000 ft. lumber	5.00
1 keg nails	3.00
Total	$34.55
Removing Side Forms.	
Labor Cost:	
Foreman, 2 hours at 50 cents	$1.00
Laborers, 71 hours at 31¼ cents	22.03
Total	$23.03
Removing Dome Forms	
Labor Cost:	
Carpenters, 133 hours at 50 cents	$66.50
Laborers, 32 hours at 31¼ cents	10.00
Total	$76.50
Backfill (Sand).	
Labor Cost:	
Laborers, 141 hours at 31¼ cents	$44.06
Teams, 4 hours at 75 cents	3.00
Total	$47.06
Setting Curb.	
Labor Cost:	
Paver, 6 hours at 75 cents	$4.50
Laborers, 12 hours at 31¼ cents	3.75
Total	$8.25
Pavement Foundation.	
Labor Cost:	
Foreman, 2 hours at 50 cents	$1.00
Laborers, 59 hours at 31¼ cents	18.43
Total	$19.43
Material Cost:	
44 sacks cement at 60 cents	$26.40
10 yd. rock at $1.50	15.00
3 yd. sand at 50 cents	1.50
Total	$42.90
Sidewalk Foundation.	
Labor Cost:	
Laborers, 16 hours at 31¼ cents	$5.00
Material Cost:	
4 yd. rock at $1.50	66.00
Catch Basin.	
Labor Cost:	
Mason, 10 hours at 50 cents	$5.00
Labor, 38 hours at 31¼ cents	11.87
Total	$16.87
Material Cost:	
800 bricks at $9	$7.20
12 sacks cement at 60 cents	7.20
Total	$14.40
Pavement Wearing Surface.	
Labor Cost:	
Paver, 28 hours at 75 cents	$21.00
Rammer, 16 hours at 50 cents	8.00
Laborers, 148 hours at 31¼ cents	46.25
Total	$75.25
Material Cost:	
1700 lb. asphaltic cement	$17.00
6 yd. gravel at $1.80	10.80
8 sacks cement at 60 cents	4.80
Total	$32.60
Sidewalk Wearing Surface.	
Material Cost:	
410 ft. asphalt finish laid at 11 cents	$45.10
Grand total	$4,611.46

THE ACTION OF FROST, ice and water on the concrete crest of the small dam on the Quinepoxet River at the head of the Wachusetts reservoir, in Massachusetts, caused a partial disintegration of the surface of the crest, according to the 1912 report of Mr. Dexter Brackett, chief engineer of the Metropolitan Water Board. A short section of the crest has been repaired experimentally by cutting out the old concrete to a depth of about 2 in. and refilling the space with a mixture of 2 to 1 cement mortar bonded to the old masonry by means of iron bolts and wire netting.

Report of Cleveland's Filtration Commission

The commission appointed by Mayor Baker to consider the scientific problems involved in determining the most suitable method of filtration for the water supply of Cleveland, Ohio, submitted its preliminary report on July 5. The general conclusions are given below. The commission consists of Dr. A. W. Smith, professor of chemistry, Case School of Applied Science; Dr. Hippolyte Gruener, professor of chemistry, Western Reserve University; Dr. W. T. Miller, member Ohio State Board of Health; Dr. Roger G. Perkins, city bacteriologist, and Mr. R. Winthrop Pratt, consulting engineer.

CONCLUSIONS

1. A filtration plant at Cleveland is necessary in order to secure a safe and suitable water supply at all times.

2. Filtration works of the rapid-sand gravity type, suitably operated, will produce for Cleveland a clean, safe water and one which will be at all times satisfactory for drinking and household uses.

3. A filtration plant of the above-named type and of about 150,000,000 gal. daily capacity should be constructed on land owned by the city east of the Division Street pumping station and immediately north of the proposed west side boulevard.

4. A filtration plant of the above-named type and of about 80,000,000 gal. daily capacity should be subsequently constructed on land adjacent to the Kirtland Street pumping station.

5. If the preliminary construction work for the west side plant were begun during the present season the plant could probably be completed early in the year 1915 and would thus be ready for use when the proposed west side tunnel is finished. The construction of the Kirtland Street filtration plant would take about eighteen months, but this work need not be begun at once, as it is the intention of the waterworks department, on completion of the west side tunnel, to supply the entire city for a time from the Division Street station.

6. A filtration plant for the west side, of about 150,000,000 gal. daily capacity, would cost approximately $1,100,000, and one for the Kirtland Street location, of about 80,000,000 gal. capacity, would cost approximately $700,000. The costs do not provide for the additional low-lift pumping machinery necessary to raise the untreated water to the filters. Such machinery, however, could be installed for less than $200,000, so that the total amount necessary to provide for the needs of the city until such time as the present water consumption is doubled would approximate $2,000,000.

7. The cost of operating the filtration works exclusive of interest and other fixed charges would be from $2 to $4 per 1,000,000 gal., according to the amount of coagulant used. On the basis of a consumption of 100 gal. per capita, this represents an annual charge of not more than 15 cents per person. The annual interest charges would be approximately 12 cents per capita additional on a basis of a population of 1,000,000.

8. The problem relative to the kind and amounts of coagulants best suited to Cleveland water, and also the question of the feasibility and desirability of softening the water, require more study. The commission desires to obtain more information along these lines by means of the test plant which has been installed at the Kirtland Street pumping station. The commission also stands ready to advise from time to time in regard to the various features of design as the work progresses on the detailed plans for the proposed filtration works.

Book Reviews

Mr. Alexander Wright, member of the San Francisco Chapter of the American Institute of Architects, has published a 46-page pamphlet on building arbitration, which describes the advantages and proper methods of procedure and gives convenient forms for use in settling disputed points of building construction. It outlines the qualifications and duties of the arbitrators, explains the proper nature of the award and discusses the suitable compensation of arbitrators and employer and suggests methods for its collection.

"List of Works Relating to Electric Welding" is the title of a booklet compiled by Mr. William B. Gamble, chief of the division of technology of the New York Public Library. The work is, as its name implies, a compendium of the published material, embracing both books and magazine articles that may be found in the files of the New York Public Library.

ELECTRIC INTERLOCKING. By the Engineering Staff of the General Railway Signal Company. Leather, 4 x 6¾; 435 pages; 283 figures. Rochester, N. Y., General Railway Signal Company, $3 net.

This handbook goes fully into all parts of G. R. S. dynamic indication electric interlocking, the first 124 pages being devoted to the system and appliances, with numerous photographic illustrations, followed by 18 pages on signal lighting, electric locking and check locking. Then come 152 pages of installation and operating data for power plants, switchboards, electric interlocking machines, switch and signal mechanisms, relays and indicators, transformers, and primary batteries, and 24 pages on wire, trunking and conduit. Ten pages are devoted to Portland cement concrete, and 32 more discuss written circuits and signal aspects and signals. In the latter part of the book are numerous tables, some applying specifically to G. R. S. apparatus and electric interlocking plants and others containing a variety of useful information for all engineers.

THE IMPROVEMENT OF RIVERS. By B. F. Thomas and D. A. Watt. Two Volumes. Cloth, 9x12. Vol. I, 369 pages, 128 text figures and 45 lithographed inserts; Vol. II, 380 pages, 121 text figures and 31 inserts. New York, John Wiley & Sons, Inc., $7.50 net.

The first edition of this book was issued in 1902; the second edition, rewritten and materially enlarged, has just been brought out.

The first volume is divided into eight chapters dealing with characteristics of river regulation, dredging and snagging, dikes, protection of banks, levees, storage reservoirs, and the improvement of the outlets of rivers. The second volume has ten chapters, treating of the following subjects: General design and construction of locks and dams, locks, lock gates and valves, fixed dams, movable dams, needle dams, chanoine wicket dams, gate and curtain dams and bridge and shutter dams, drum wickets and beartraps and rolling dams, and accidents to structures.

The book is unusually complete. It deals not only with what has been done in the United States but is an encyclopedia embracing good practice in river regulation in all parts of the world. The well-chosen illustrations should make the book exceedingly valuable to designers in any line of hydraulics. In the chapter entitled "Lock Gates and

Valves" there is an apparent misstatement. It is claimed that 24-in. beams are cheaper than built-up girders. Every designer of steel structures knows that the point at which the built-up girder becomes cheaper than the rolled beam is at a 15-in depth. Furthermore, the two distinct types of steel-beam gates are not clearly differentiated. There is one type known as the elastic type, in which the horizontal girders are supported on X or sawbuck bracing and where the skin plate has only rolled shape stiffeners, if necessary to assist in carrying the loads to the girders. This type is mostly used abroad. Then, there is the "stiff" type, where rigid vertical beams are introduced to prevent the gate from collapsing should it take a bearing on the miter sill and fail to miter. This type, advocated in Lieutenant-Colonel, then First-Lieutenant, Harry F. Hodge's paper, "Mitering Lock Gates," is now generally adopted by lockgate designers in the United States—for instance, in installations of such magnitude as Panama and Keokuk. The Keokuk gates are arched, though, with this stiffening element added to them.

The filling and emptying of a lock chamber is an important subject, rather too briefly treated in this work. It is generally not considered good practice simply to by-pass the lock gates with culverts, especially for large lock chambers. The authors, therefore, point out that the longitudinal culvert has come into much favor both in America and Europe. The arrangement of the discharge-distributing openings from this culvert so as to cause the least motion in a ship in the lock is not even touched upon. The Swedish Government for a number of years has been making experiments along these lines.

The chapter on movable dams has some interesting types to offer, especially the part dealing with rolling dams, a type little known in the United States. So far only two installations have been made in this country, one at Spokane and one on the Boisé Irrigation Project in Idaho. This chapter, therefore, could well have dealt in more detail with the subject of rolling dams, for they are a big factor in economic dam construction, where the regulation of large rivers is in question, because of the possibilities of large and deep discharge openings.

Letters to the Editor

Method of Checking Economical Height of Office Buildings

Dear Sir: The method proposed by Mr. C. T. Coley for determining the proper height of a skyscraper, as presented on page 21 of your issue of July 5, is one of those demonstrations that are pretty on paper but not as scientific or useful as they appear at first glance on account of the large number of assumptions and approximations.

Let us see the result of varying some of these assumed figures, as applied to the parcel worth $300 per square foot. Accepting the interest rate at 5 per cent, the tax rate could readily be $1.90 instead of $1.83 per $100 valuation, giving $5.70 per year per square foot for the parcel in question. This added to the $15 and divided by 95 per cent would give $21.80 to be earned on each square foot occupied by the building. If we assume that in this particular building only 62 per cent of the area is rentable (this per cent would be the less the higher the building), the land-carrying charge would be increased to $35.10 per square foot of land over which there is 1 sq. ft. of rentable area per floor.

Using the same 62 per cent, with 12 ft. as the average distance between finished floors, the volume of building per square foot of rentable floor will be 19.3 cu. ft. Mr. Coley admits that the cost per cubic foot may vary from 80 cents to $1. Let us suppose that the foundations of our skyscraper will be expensive and that the average cost per cubic foot will be 90 instead of 80 cents. Then the cost of securing 1 sq. ft. of rentable area, 90 cents multiplied by 19.3, will be about $17.40.

Maintenance costs are capable of wide deviation, and the figure of $1.15 per square foot given by Mr. Coley can be increased to $1.25 without a stretch of the imagination. The average rent obtainable may average only $3.40 per square foot, and the loss of rent may easily amount to 12 per cent, or 41 cents, making the total cost of maintenance $1.66. Interest at 5 per cent on $17.40 is 87 cents. Allowing the depreciation and amortization fund of 30 cents to remain for the moment undisputed, the cost per square foot of rentable area will be $2.83 instead of $2.54. This, with the decreased rent rate, will reduce the net profit per square foot from 96 cents to 57 cents per floor, and in order to earn the $35.10 per square foot of lot area under rentable floor area the building will have to be sixty-two stories high.

By similar changes in the figures in the opposite directions it can be readily shown that a building of twenty-two stories will "fill the bill." It will be seen, too, that in each case the deviations are small—quite within reason. Some of them, in fact, are very conservative. For instance, in a sixty-two-story building probably considerably less than 62 per cent of the total floor area would be rentable, and the cost per cubic foot would probably be much more than 90 cents. So, too, if the depreciation allowance were based, as it perhaps should be, on 3½ per cent instead of 4 per cent interest that figure would be entiirely changed.

The method proposed by Mr. Coley does not take into account the size or shape of the parcel of land, which would have a large bearing on the light courts and rentable area. My point is, however, that even though his assumptions are based upon experience and careful observation and are as close as they could be figured in advance, they are, after all, only approximations, and their combination in the manner set forth by Mr. Coley does not seem conducive of results of much value.

New York. G. W. WOLCOTT.

Valuation of Steam Railroads

Dear Sir: The two articles entitled "Valuation of Steam Railroads" appearing in the Engineering Record of June 14 and 21, and abstracted from a paper by Mr. William J. Wilgus, M. Am. Soc. C. E., certainly deserve creditable mention and should be widely read.

From the standpoint of one who has experienced the tendency of state appraisals covering steam railroad and other public utility properties the presentment of Mr. Wilgus is clear, frank and sound. Although some of the matters are debatable, and in some instances others will disagree more or less with the arguments presented, especially in view of the impending important work of the appraisal board of the Interstate Commerce Commission, the paper will lead to a very thorough perusal and weighing of each important step. Certainly Mr. Wilgus has attacked the important questions in a fair, equitable manner and whatever differences in opinion may be evolved the consequent discussion and study should be undertaken in the same spirit. As he says, the work of evaluating the steam-railroad properties of the United States is a very great task, and the results may be of great importance. Considering the task, unbiased facts, mature judgment and equity to all parties should be the slogan. Articles such as that of Mr. Wilgus will certainly assist in securing the proper consideration of the many problems involved.

E. C. HURD,
Engineer, Nebraska State
Railway Commission.
Lincoln, Neb.

Wearing Qualities of Concrete Floor Surface

Dear Sir: Replying to F. W., of Montgomery, Ala., in re cement floors in the June 21st issue of the Engineering Record, it looks to me as if a very young architect or a cement salesman had written the specifications for the floor of which F. W. speaks, as in four years' experience on floor and sidewalk work I never knew an engineer to specify a richer mixture than 1 part cement to 1 part stone or sand, and that was generally considered among the sidewalk contractors to be bad practice.

My own experience has been that the best results were obtained from a mixture of 1 part cement and 2 parts stone screenings and stone dust mixed, the stone, of course, being some hard variety such as granite or trap. I have in mind particularly one floor laid in a paper warehouse which after two years' use was shiny.

Cement in excess of that necessary to fill the voids in the stone only causes crazing.

I should think that 20 x 30-ft. panels would make a better division than 30 x 40, and that a 1-in. top is just as good as 1¼ in., besides being 20 per cent cheaper.

If the top is placed within half an hour after the base is laid there would be no trouble with the bond with a 1:2 top; with the one specified there might be, but I should think it doubtful.

From personal observation of several hundred jobs I think that most, if not all, of the cases of the top coat separating from the base are caused by putting in the base too dry, allowing the base to set before applying the top, getting sand or other foreign matter on the base before applying the top, thus ruining the bond between the two layers, and finally making a sand joint in the base and not cutting the top through.

The writer laid about 3500 lin. ft. of concrete road from 8 to 12 ft. wide with 1:3:6 base and 1:2 sand top, and had absolutely no trouble with it. This was laid in sections 30 ft. long, with a 1-in. cypress expansion strip every 30 ft. Six months after laying there was no sign whatever of any separation between base and top.

On this job the base was laid very wet and put into place with a shovel, no tamping whatever being done. The top was often laid not more than fifteen minutes after the base was placed, and was also very wet. It was floated with a wooden float as soon as possible and then covered with 1 or 2 in. of sand, which was left on for at least a week, and frequently wet.

CHARLES H. JOHNSON,
Superintendent and Foreman,
Public Works Department.
Guantanamo, Cuba.

Code of Ethics of the Pacific Northwest Society of Engineers

Dear Sir: The writer has read with a great deal of interest and with hearty approval the code of professional ethics recently adopted by the Pacific Northwest Society of Engineers and printed in the Engineering Record of July 12, page 50. Evidently the engineering millennium is approaching in the United States from the West. It is to be hoped that every member of the Pacific Northwest Society will live up to this code in full, for it will certainly add much to the effectiveness as well as to the pleasure of engineering practice in that part of the country. It will be very hard, however, not to criticise adversely a brother engineer's plans, especially when a good fee is in sight, and it might be well to guard especially that provision of the code. This tendency, together with the more pernicious one of underbidding, is, in the writer's opinion, the most harmful in the profession, but both are common, and always will be to some extent, as they are in other professions. Every effort should be made to check both and some form of penalty should be provided for violation. In this regard the code is lacking.

How is the code to be enforced? Indeed, how is any measure determined by a majority of the profession to be enforced, as the profession now is, with no status in law and no legal requirements for practice? We may turn an offender out of our societies, frown upon him ourselves, but he can go right on with his nefarious practice, injuring the reputation of the profession. Does not this view of the matter emphasize again the need of some form of license law? Any form of professional ethics we may adopt is empty indeed unless backed up by some form of statute law, which can be used to prevent further practice by those who violate.

Down in Mississippi recently a lawyer acquaintance of mine was disbarred for unprofessional practice. If he had been an engineer he could have committed an offense equally as heinous, and, save for censure from his professional brethren, he would have suffered small inconvenience. Nothing can be done to enforce professional ethics until we have some form of engineering law.

The writer would like to suggest an addition to the code of ethics, and this in the interest of the dignity of the profession. It is that the members of the society agree not to enter into any competitive contest in supplying plans. The writer has taken part in several farces of this kind, and he believes this foolish practice is responsible for the failure of many engineering structures. At the present time he has on file a set of plans for a small bridge. The bridge commissioners met and under the persuasion of contractors agreed to have competitive plans. The writer argued in vain that this really was no competition, as not a member of the commission knows one thing about bridge design. The engineers entered into it eagerly. The commissioners failed to see that as the writer was upon salary and got no fee for his plans he had no inducement to cut the bridge to dangerous limits, while the scheme adopted offers every temptation to others to do that very thing.

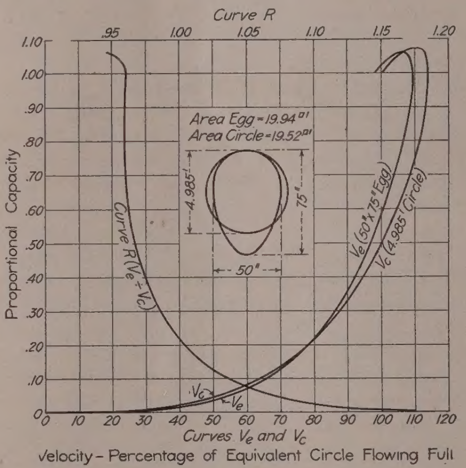
A few years ago the writer was called in a consulting capacity to aid a building committee, composed mostly of lawyers, to select a plan from a number offered for a large building. To his amusement, as each engineer presented his plans, the chairman of the committee informed him that his plans would not be considered unless he would furnish bond that his building could be constructed within the specified sum. Some of the engineers refused to acquiesce and withdrew. The writer tried to make the folly of it clear by asking the lawyers if they would give bond guaranteeing to win a case committed to their care; but all to no purpose. An engineer was at length found who agreed to do this thing for them.

How is the profession to be got rid of such nonsense and the public brought to regard and treat it as a real profession without a license law? If someone will propose a better plan, the writer will gladly accept it. Let us have something that will work and not be an empty form of agreement upon paper.

Lebanon, Tenn. Walter H. Drane.

Comparison of Egg-Shaped and Circular Sewers

Dear Sir: Sanitary engineers adopt egg-shaped sewers in preference to circular-shaped sewers generally because of the hydraulic advantage of the egg-shaped sewer when carrying relatively small quantities of sewage. This advantage and that of a narrower trench must overbalance the advantage of the circular sewer in strength, economy of section, and depth of cut.



Hydraulic Comparison of Equivalent Egg-Shaped and Circular Sewers

Kutter's formula, $n = 0.013$; $s = 0.001$; 50 x 75-in. egg equivalent to 4.985-ft. circular.

All rights to the above drawing are reserved by the authors, to whom application should be made for permission to reproduce it.

The accompanying diagram is a hydraulic comparison of a 50 x 75-in. egg-shaped sewer with the circular-shaped sewer of equivalent capacity when both are flowing full on a 0.1 per cent grade, their common friction factor being 0.013. While this is a particular case, the hydraulic ratio will hold true for all practical purposes throughout a considerable range of conditions. The curves V_c and V_e give the velocities of equal quantities of sewage flowing in the two types of sewers. They are expressed in terms of the velocity of the sewage in the circular-shaped sewer when flowing full. The curve R gives the relative velocities of the same proportional quantities of sewage flowing in the egg and circular-shaped sewers.

We believe that this comparison is much less to the advantage of the egg-shaped sewers than engineers have generally supposed.

Sewer Division, O. L. Eltinge,
Kansas City, Mo. R. S. Beard.

Micro-Organisms in Water

Dear Sir: The writer is much interested in the letters appearing in the Engineering Record of June 14, page 676, and July 12, page 56, concerning filter troubles from micro-organisms at the Evansville and Moline filter plants. Similar troubles of clogging of the sand, causing short filter runs and the presence of odors have occurred for periods of varying length each spring and summer at the Louisville filter plant for the last four years.

Frequent microscopical examinations of the water are made during these periods and we find that the diatoms are always the chief offenders with melosira, synedra and asterionella predominating. During these periods there is usually a large amount of amorphous matter present in the water, which probably tends to cement the sand grains and promote clogging. At Louisville this clogging has several times shortened the periods of filter service to one and a half hours. One application of 1.5 parts per million of copper sulphate in one of the settling basins of two days' capacity will usually relieve the trouble and give an increase in filter service. The odors are not troublesome, as they occur only in the raw water and are never noticeable in the filtered water.

The one bad feature in the use of copper sulphate is the aftergrowth, or large increase in bacteria in the water resulting from its use. We have experienced increases frequently from about 500 bacteria per cubic centimeter in the water before treatment to 200,000 in the same water twenty-four hours after treatment, and it is usually four or five days before the bacteria decrease again to normal. The bacteria present in this aftergrowth are always of the ordinary harmless water forms, with very seldom even evidence of colon forms. However, the presence of abnormally large numbers of bacteria, even though no intestinal forms accompany them, spoils the records of a plant and is rather difficult of explanation to the ordinary citizen. For these reasons I would advise that, wherever possible, the copper treatment be followed by the application of hypochlorite to offset the bacterial increase due to the former.

W. H. Lovejoy.

Crescent Hill Filters,
Louisville, Ky.

Raising the Assuan Dam

Dear Sir: We read with considerable interest your article on the Assuan Dam, but are sorry to note that you only give the name of Messrs. John Aird & Company in connection with the contract.

We would inform you, however, that we received the contract direct from the Egyptian Government for the alteration of the metalwork involved by the heightening of the dam, and also the provision of two new lock gates, the swingbridge and various other items mentioned in your article.

Might we ask you to kindly notice this fact in your next issue?

Ransomes & Rapier, Ltd.,
Wilfrid Stokes,
Chairman and Managing Director.
London, England.

Highway Inspectors in the Philippines cover the work in their respective districts on motorcycles. The scheme is said to be satisfactory, enabling the inspectors to make more frequent visits to various jobs.